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SURGERY OF THE BRAIN AND SPINAL CORD

BASED ON PERSONAL EXPERIENCES

BY

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VOLUME III

*WITH 42 FIGURES (3 OF WHICH ARE COLORED) IN THE TEXT, AND
47 COLORED FIGURES ON 22 PLATES*

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In Volume I, observations have frequently been referred to that are described at length in Vol. II and Vol. III. It was therefore thought expedient to make the following changes in this part of the work.

Observation IV, 2, p. 61, changed to Observation X, 9, p. 882.
Observation XI, 1, p. 202, changed to Observation VI, 3, p. 658.
Observation XIV, 3, p. 185, changed to Observation X, 4, p. 857.

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THE SURGERY OF THE BRAIN

Neoplasmata at the Base of the Skull

Neoplasmata of the base of the skull are closely allied to tumors at the base of the brain. Newformations originating in these cases from the outer (lower) surface of the dura or from the bone itself grow, as a rule, into the cranial cavity and may give rise to manifestations of cerebral compression as well as to morbid symptoms from involvement of the cerebral nerves. A differentiation as to the structures from which the tumor originated is, from the clinical manifestations alone, frequently impossible. However, the Roentgen picture may, in certain cases, show a sufficient number of changes in the bone to lead to a correct diagnosis. I have frequently operated on cases in which the typical symptomatology clearly pointed to tumors at the cerebello-pontine-angle, and in which the operation disclosed the existence of extensive tumors that had destroyed the posterior surface of the petrous portion of the temporal bone, and had, therefore, originated either from the outer surface of the dura or from the petrous portion of the temporal bone itself. To discover such tumors, no method is at present at our command other than an intradural exploration through the posterior fossa of the skull. X-ray examinations have thus far invariably disappointed us; maybe because of the deep position of the tumor near the median line. Furthermore, if not situated in the lateral sections of the base of the skull, such neoplasmata of the dura and of the bone (mostly sarcomata) are, as a rule, not amenable to radical removal. It would be a great aid to the surgeon, if X-ray examinations threw more light upon the actual state of affairs in these cases, for we would then limit our surgical interventions to simple decompression-trephining.

The petrous portion of the temporal bone constitutes a site of predilection for the invasion by neoplasmata. Osteosarcomata spring from the bone itself, psammomata and sarcomata from the dura covering it. If they restrict the space of the posterior fossa of the skull, these tumors will produce the same manifestations as will those involving the cerebellum proper.

With reference to the latter conditions, I shall cite the following example: A girl, eighteen years of age, was admitted to the Augusta Hospital with all symptoms of cerebellar tumor

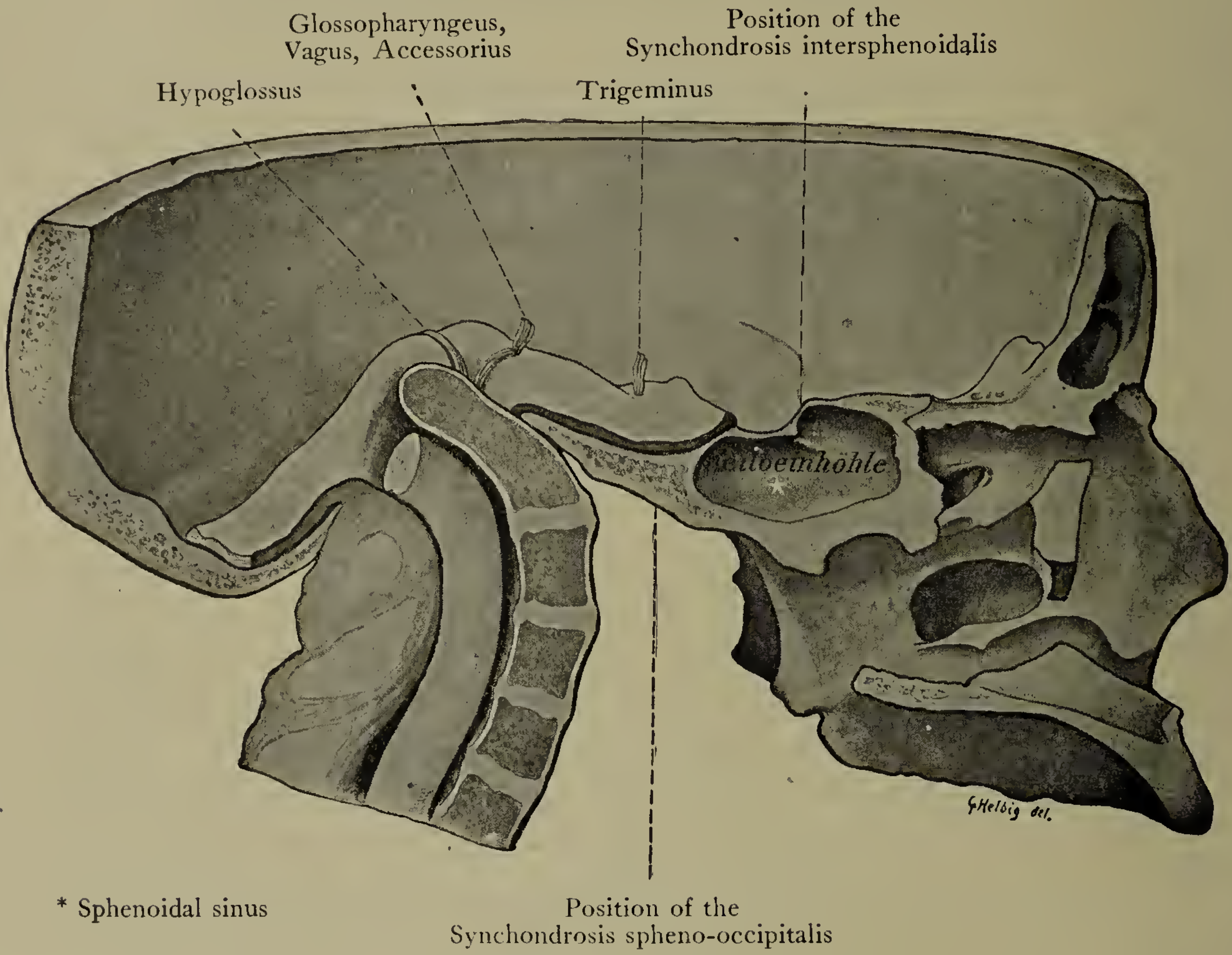
Glossopharyngeus, Vagus, Accessorius
Position of the Synchondrosis intersphenoidalis
Hypoglossus
Trigeminus
Keilbeinhöhle
G. Helbig del.
* Sphenoidal sinus
Position of the Synchondrosis spheno-occipitalis

Fig. 144
Kyphosis of the Base of the Skull. Sagittal Section

(marked choked disc of both sides, cerebellar ataxia, vertigo even in the dorsal decubitus, daily vomiting, paroxysms of excruciating pains in the back of the head and neck, rigidity of the back of the neck, and opisthotonus), all the manifestations enumerated having developed within a period of one year. During all this time, her psychic condition remained undisturbed. We were not able to establish definitely on which side the neoplasm was located, and we were, therefore, compelled to expose both cerebellar hemispheres. No tumor was found; but in its stead a great reduction of space within the posterior fossa of the skull, occasioned by an enormous kyphosis of the basis cranii in the posterior region of the sphenoid bone and the pars basilaris of the occiput. After the operation, the symptoms improved; but soon thereafter manifestations of cerebral compression set in anew, when the patient expired.

Fig. 144 depicts the remarkable specimen concerning which I have reported on another occasion.[1] For the sake of comparison and clearness, I have inserted here Fig. 145, which

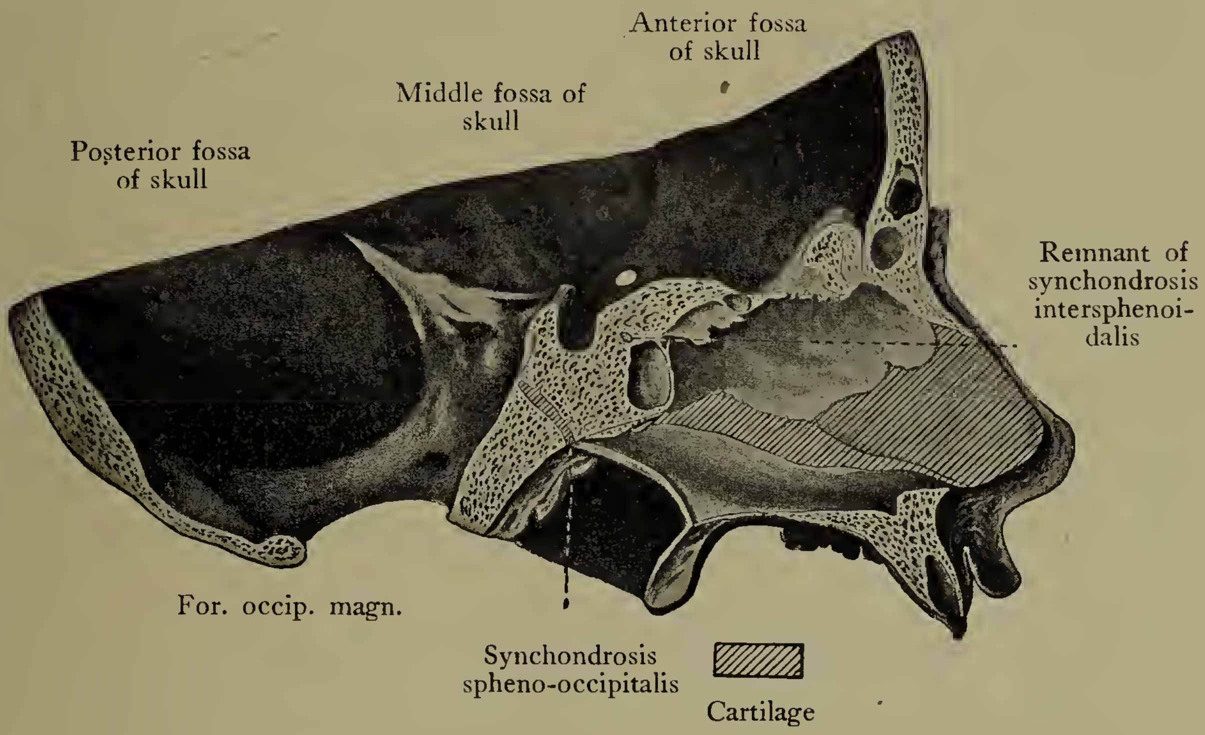

Fig. 145

Sagittal Section of the Skull and Face of a Girl Thirteen Years of Age, from *Rudolf Virchow's* "Untersuchungen über die Entwicklung des Schädellgrundes," Berlin, 1857, by Georg Reimer, Plate III, Fig. 5, $\frac{3}{5}$ of normal size.

shows the normal relations of the parts in a girl thirteen years of age.

The deformed base of the skull seems to indicate that it was not resistant enough to support the weight of the head on the cervical portion of the spinal column, in the region of the clivus *Blumenbachii* and in the adjacent portions of the foramen magnum; and that this region had been pushed forward toward the interior of the skull, thus producing a pathologic prominence that projected about ½ cm. over the superior border of the pyramid of the temporal bone. This prominence apparently resulted from an abnormal softening of the osseous structures in question (rickets). It therefore becomes at once apparent that the great deformity and restriction of space within the posterior fossa of the skull, consequent to the prominence just spoken of, simulated the manifestations of neoplasm of the cerebellum. Since the morbid manifestations did not appear until about a year before the patient was admitted to the hospital—when she was seventeen years of age—we are justified in assuming that, although the changes in the base of the skull were gradually developing, the acme of the deformity was reached in that year, and gave rise to symptoms of cerebellar tumor.

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[1] *F. Krause*, Zur Freilegung der hinteren Felsenbeinfläche und des Kleinhirns. *v. Bruns*, "Beiträge zur klinischen Chirurgie." Band XXXVII, 1903.

In cases where the middle fossa of the skull is in question, the early appearance of the characteristic visual disturbances point to a tumor which has its origin at the base of the skull, and not in that of the brain. Late development of hemiparetic manifestations that may be looked upon as distant symptoms resulting from an interference with the conduction of the motor tracts are, from a diagnostic standpoint, of the same value.

Neoplasmata of the Gasserian Ganglion

Neoplasmata of the *Gasserian* ganglion deserve special consideration. The clinical symptomatology in these instances corresponds mainly to the involvement of the branches of the trigeminus. The patient may suffer from pain in all three branches. This pain is, as a rule, different from that of genuine paroxysmal neuralgia of the trigeminus—it is usually continuous. The pains are associated with disturbances of sensation, and the cornea may become anæsthetic as a result of paralysis of the nervus ciliaris longus. Pareses and paralyses of the muscles of mastication are explained on the same basis. Trophic disturbances of the cornea and in the accessory sinuses of the nose (fluid collections in the antrum of *Highmore)* are occasionally met with. The case of the patient described in Observation VIII, 1 Vol. II, p. 785, deserves special notice. It will be recalled that in this instance the patient did not complain of pain at any time, despite the fact that the entire *Gasserian* ganglion was involved in the tumor mass; and that anæsthesia of the conjunctiva and cornea, with subsequent neuroparalytic keratitis and hypalgesia of the corresponding half of the tongue, developed later. An increase in the size of the neoplasm of the *Gasserian* ganglion affected sympathetically the neighboring nerves—especially the olfactorius and the nerves of the ocular muscles.

It must be mentioned here, however, that there are cases of tumor of the base of the brain which cause typical trigeminus neuralgia without involving either the region of the ganglion of *Gasser* or the trigeminus proper.

In unilateral tumors of the base of the skull, *Hartmann*[1] distinguishes two types of clinical pictures—the trigeminus type and the acusticus type. In the differential diagnosis, he emphasizes the importance of the primary clinical symptoms and the anatomic location of the tumor. Under the heading of the trigeminus type, he embraces all those neoplasmata that develop primarily from the trigeminus and, consequently, cause primary manifestations from that nerve. It is said that symptoms of general cerebral compression, especially choked disc, are, in these cases, wanting, and that they occur only in instances of carcinoma of this region. On account of the anatomic location of the trigeminus, the development of neoplasmata is extradural, at least in the beginning of the disorder, and frequently so throughout the disease. We are, consequently, dealing with actual newformations at the base of the skull.

In the second class, the acusticus type, the beginning of the trouble is marked by acusticus manifestations which are in the foreground of the clinical picture. This form of the disease contrasts with the former type by the presence of symptoms of cerebral compression and frequently by choked disc. Neoplasmata of the acusticus develop intradurally and, therefore, in my opinion belong to neoplasmata at the base of the brain. For this reason they are discussed under that heading.

As stated in the beginning of this chapter, neoplasmata of the base of the brain and the skull cannot always be separated from one another. This is more so the case, since the tumors are occasionally partly intra- and partly extra-dural, so that both portions are united only by a pedicle perforating the dura.

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[1] *Hartmann,* Beiträge zur pathologischen Anatomie und Klinik der Geschwülste der Basis. "Jl. für Psychol.," VI and VII.

Neoplasmata only rarely originate in the *Gasserian* ganglion itself. They most frequently commence in the nerve-sheath or in the dura covering it. *Marchand*[1] described a tumor which according to the clinical symptomatology and the histologic examination, had originated from the ganglion itself. He concludes from his microscopic studies that there is a great probability of the tumor originating from the ganglion matrix of the indifferent stage. He, therefore, calls it "neurocytoma." The usual types of tumor encountered are mainly sarcomata, less frequently endothelioma, cholesteatoma, and chondroma. Carcinomata are usually of a metastatic nature.

Operations in these cases are mainly performed for the relief of pain. A radical cure is very rarely obtained. The patient may nevertheless be relieved of his sufferings and his life prolonged. The operation consists of extirpation of the *Gasserian* ganglion. The technic is described below.

Extirpation of the Gasserian Ganglion

At first I fashion, in the region of the temporal muscle, a flap with downward base which consists of skin, fascia, muscle, periosteum, and bone (see Plate XLI). The incision begins immediately above the zygomatic arch which need not be injured at all, and close in front of the tragus; ascends in a convex manner, inclining somewhat to the back; and circumscribing a semicircle, it then descends forward to the zygoma again in such a manner that the base of the flap measures 3½ cm., its height 6 cm., and its greatest width above, 5 cm. The entire operation is performed extradurally.

As a preliminary step, *Heidenhain's* deligations are inserted, after which deligation, the incision divides all the tissues down to the bone. The periosteum is then pushed somewhat to the side, and the skull is opened in the line of the incision. A hole is bored with a *Doyen* burr at the upper border of the flap, and the bone divided with *Dahlgren* forceps. Bone-levers

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[1] *F. Marchand,* Beitrag zur Kenntnis der Geschwültse des Ganglion *Gasseri.* "Rindfleisch-Festschrift," Leipzig, 1907.

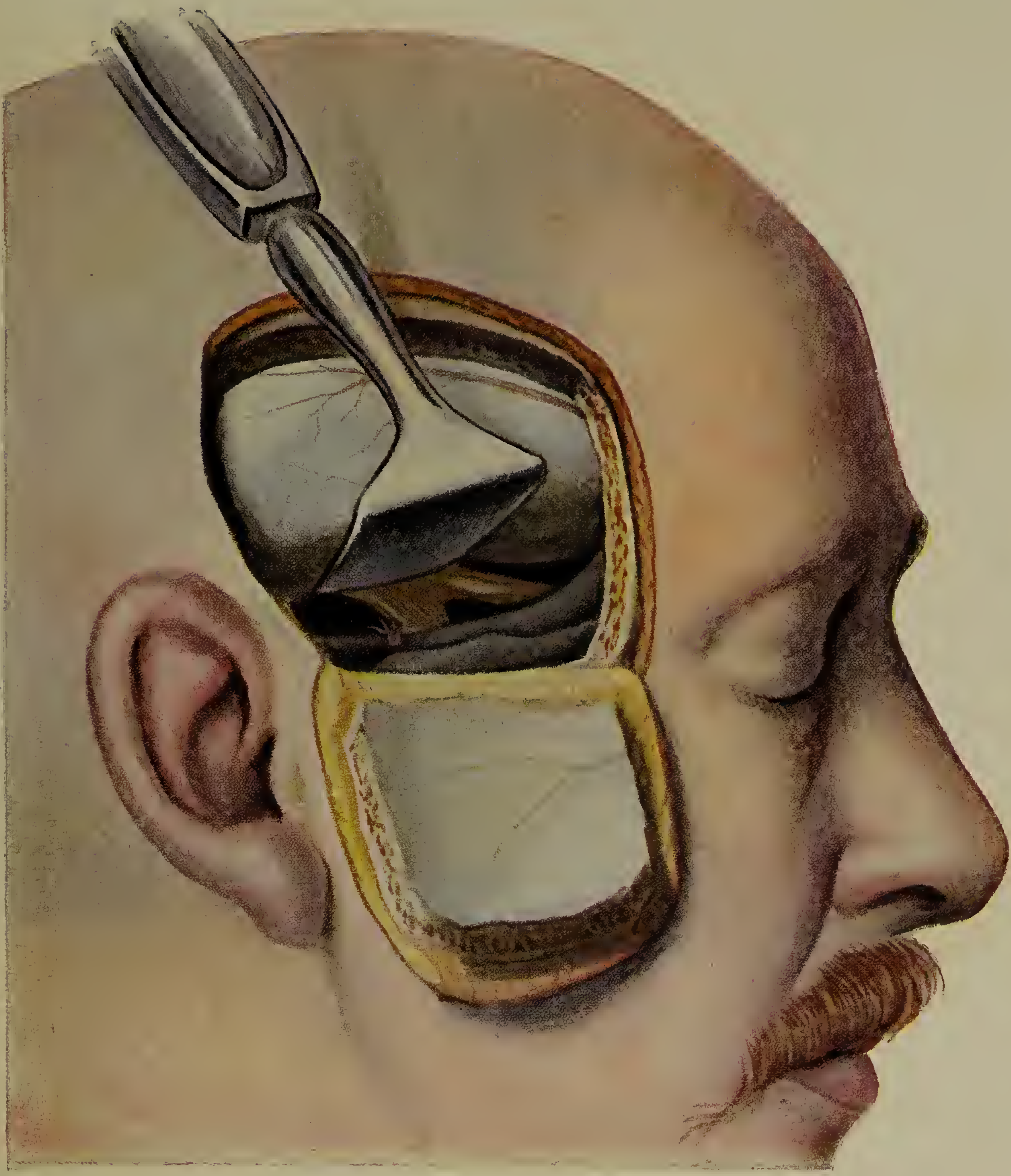

Fig. a.

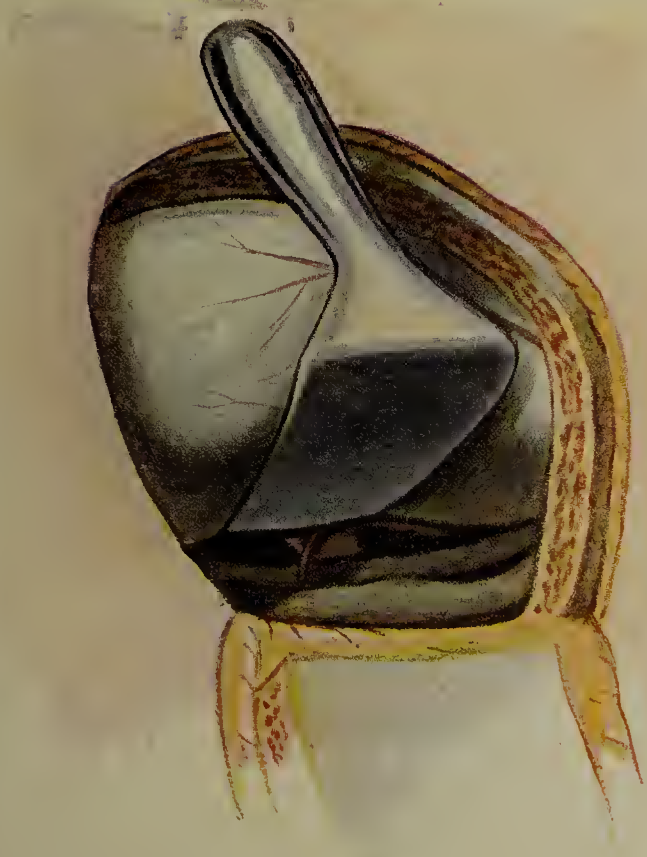

Fig. b.

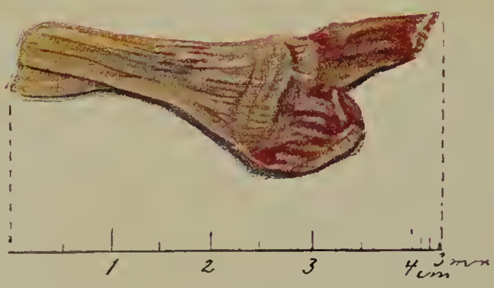

Fig. c. (Maßstab 1/1)

then help to break the bone off and displace it downward. The line of fracture of the bone is situated a little above the zygomatic arch. Any remaining ledge of bone that may impede thorough inspection is now snapped off with rongeur forceps down to the base of the skull—to the crista infratemporalis. This precautionary measure should never be omitted, because the base of the skull should always lie freely exposed.

After the flap is reflected, it is seized with a pair of my claw-forceps (see Fig. 9, Vol. I, p. 19); and flap and forceps are together wrapped up in a sterile gauze compress and permitted simply to hang down at the side of the patient, who is in an almost sitting position. The dura is now freely exposed. If it be very thin and closely united with the lamina vitrea, we must be especially cautious not to tear it while removing the bone, for such an accident would render the operation extremely difficult.

The finger, aided by a dull raspatory, is now inserted between the osseous base of the skull and the middle fossa; this is accomplished by carefully separating the dura mater from the upper surface of the base of the skull. We now reach the foramen spinosum and the branch of the middle meningeal artery coursing in the dura mater which it enters. The ligation of this vessel is now begun, and, while this is being done, an assistant carefully lifts the brain enclosed in the dura mater with a spatula (see Fig. 27, Vol. I, p. 115). This lifting should be carried only to such a point as is absolutely necessary to render the parts visible.

As a rule, the dura appears very tense immediately upon opening the cranial cavity; but it soon becomes flaccid, and gives ample room for inspection and for carrying out the other steps of the operation. When the dura is elevated, the two veins accompanying the middle meningeal artery become visible as a distinct cord leading to it from the foramen spinosum. Further detachment of the dura mater from the base of the skull with the elevator, toward the median line, exposes the second and third branches of the artery, and the entire bundle of vessels is freely isolated on all sides (compare Plate XLI, Fig. b). The artery may in this manner be exposed to an extent of about $\frac{1}{2}$ cm., and a threaded, flexible ligature carrier passed behind it without difficulty. A *Péan* hemostat is now applied to the artery, between the dura mater and the foramen spinosum, and the vessel is ligated. The artery forceps are now removed, and the vessel is severed close to the dura. The artery is isolated in such a manner that, should the ligature slip accidentally, enough is left of the vessel to grasp it again. In such cases, it is best seized with two dissecting forceps on account of the depth of the wound. This method is so simple, that I am using it in other cases of typical **ligation of the trunk of the middle meningeal artery.**

Dollinger practised extirpation of the ganglion without ligating the artery. That this is possible, I can testify from personal experiences. In these cases, however, the foramen spinosum was situated at an unusual distance posterior to the foramen ovale. However, the safest way to operate is to ligate and sever the vessel, and this should be a principle rigorously adhered to. Whenever a ligature slips or cuts through the artery (marked atheromatosis), I insert into the opening a blunt-pointed bone hook (see Fig. 12, Vol. I, p. 23), force it in with a raspatory and twist it back and forth a few times until the bleeding ceases; or, I allow it to remain *in situ* throughout the entire operation.

After the middle meningeal has been dealt with, the spatula rests, and the dura is further detached by cautiously advancing with a dull raspatory toward the median line. Care should be taken not to interfere with the brain by compressing it. The detachment of the dura mater from the bone may also be successfully accomplished by pressing upon it with pledgets of gauze held in the grasp of *Péan* forceps. In some cases, the operation has to be suspended for a few minutes to control the hemorrhage. I then loosely pack the wound to its deepest part by inserting sterile gauze between the spatula and the base of the skull. The gauze compression arrests the bleeding from the bone, and when the brain with its dural enclosure is permitted to fall back into its normal position, the bleeding from the veins of the dura also soon ceases. Should the bleeding not stop after these measures, as exceptionally happens, a little more packing will control it.

To control the venous hemorrhage *v. Bergmann* recommended setting the patient up and to cause the brain to sag to its normal position. I have my patients in the half sitting posture from the very beginning. It is frequently observed that a slight shifting of the spatula or its displacement to the front or back is sufficient to stay the bleeding from the veins of the dura. The length of the cerebral spatula is 8 cm. In crania of extraordinary width, it may be advantageous to increase the length of the spatula by 1 to 2 cm. It should elevate the brain with its dural covering a little upward and should not displace it to the median line.

The cerebral spatula is placed in proper position, and the third, and then the second branch of the nerve (situated farther medianward) are carefully dissected away from the ganglion of *Gasser*, with the elevator, as far as the foramen ovale and canalis rotundus. To accomplish this, the dura mater is pushed away from the nerves, which are then lifted off from the underlying bone (compare Plate XLI, Fig. a). The same procedure is now applied to the *Gasserian* ganglion itself and succeeds entirely. However, thin, isolated connective tissue bands here and there have to be severed frequently with the point of the scissors. Generally, blunt pressure with sponges held in slender holders is sufficient. Occasionally the dura is suffering a small tear which is then followed by a discharge of liquor cerebrospinalis. This, however, is of no significance, provided asepsis is faultless.

The delivery of the ganglion is facilitated by grasping the third branch of the nerve with a *Péan* hemostat and making it taut by pulling upon it. For this reason and because they steady the ganglion the branches should be divided last. I have succeeded in exposing the ganglion, in all cases, to its inner border and far enough backward toward the superior border of the petrous portion of the temporal bone, to render the trunk of the trigeminus visible. The ganglion appears like a network of fibres and is grayish-red in color, while the trunk of the trigeminus is almost white and is striped longitudinally. The ganglion is finally detached from the underlying bone. It lies now entirely free, together with the second and third branches.

The first branch of the trigeminus is purposely divided close to its connection with the ganglion and not laid bare in its further course, because it runs to the front in the wall of the sinus cavernosus. We also find in its immediate vicinity the abducens and the trochlearis, and, farther toward the middle, the oculomotorius. Great care should be taken to avoid injuring these nerves.

Should the sinus cavernosus be injured accidentally the alarming hemorrhage following may be arrested by compressing the bleeding point with a gauze sponge held in the grasp of forceps described above. Permitting the brain to return to its normal position will by itself cause the hemorrhage to cease. Otherwise a strip of gauze will have to be pressed into the bleeding region and its end brought to the surface through the wound. The pressure within the sinus is very low.

With a pair of grooved forceps, the exposed *Gasserian* ganglion is now seized transversely in its posterior portion, at the point of transition to the trunk of the trigeminus and, consequently, near the upper border of the petrous portion of the temporal bone and close underneath the sinus petrosus superior. Plate XLI, Fig. c, shows the grooves left by the forceps on the *Gasserian* ganglion. In applying the forceps, the greatest care should be exercised to prevent its point from grasping any of the structures located medianward from the ganglion—even the smallest bit of dura.

A pointed tenotomy knife, or a small pair of scissors, divides the second and third branches close to the intracranial opening of the canalis rotundus and the foramen ovale. The forceps grasping the *Gasserian* ganglion is now slowly turned around on its axis. The whole ganglion always follows and with it a larger or smaller portion of the central part (posterior to it) of the trunk of the trigeminus. The first branch usually tears off close to the ganglion. Fig. c, on Plate XLI, shows the *Gasserian* ganglion (natural size) extirpated from a man thirty-two years of age. The first branch of the trigeminus having been torn off is not present; the second is the thin, long portion; and the third, the short part. To the left of the *Gasserian* ganglion, on which the imprint of the grooves of the forceps is seen, we recognize the trigeminus trunk, the sensory and motor root.

The peripheral stumps of the second and third branch are finally pressed deeply into the canalis rotundus and into the foramen ovale with an elevator, and the lower surface of the cavum *Meckelii,* that has been entirely freed from its contents and lies before us exposed in its entire extent as far as the superior border of the petrous portion of the temporal bone, is once more carefully inspected. The foramen ovale and the intracranial opening of the canalis rotundus are now found empty. The bone is freely exposed everywhere except close behind the foramen ovale, where at times in its stead, a grayish-red mass of firm fibrous or fibro-cartilaginous structure will be found which in some cases forms the upper lateral wall of the carotid canal and together with a thin periosteal layer, forms the only partition between the lower surface of the *Gasserian* ganglion and the large artery immediately before its entrance into the cranial cavity. I have found this relationship between the anatomic structures in a number of cases. For that reason, I think the detachment of the *Gasserian* ganglion should be accomplished by blunt dissection. No instrument with sharp edge or point should be used.

The carotid artery is also closely related to the inner border of the ganglion and the trunk of the trigeminus, at the point where it emerges from the canal. However, it is sufficiently distant to escape injury during the operation, if the necessary care is exercised. It is also closely related to the sinus cavernosus. Careless operation advancing over the median border of the trunk and the ganglion (too much inward) will result first in a tearing of the sinus which will cause troublesome and warning hemorrhage.

In none of my operations has the internal carotid ever been injured. I recall the case of a man twenty-six years of age, on whom the operation had to be performed in two stages on account of an annoying venous hemorrhage. In this instance the internal carotid lay, at the conclusion of the operation, freely exposed in its course from the canal in the petrous portion of the temporal bone to its entrance into the dura mater. Over it, the three nerves of the ocular muscles were seen. The artery was not injured.

My experiences with over seventy extirpations teach, that under ordinary circumstances, preference should be given to the method just described. Modifications of the technic which I have also tried on the living subject offer no advantages over this method. My views in this respect entirely coincide with those of *J. Hutchinson,*[1] of London, who used *Horsley's* material for the preparation of his monograph on the subject. Where the cerebral tension is high, the dura may be scarified to drain off the liquor.

Temporary resection of the zygomatic arch as well as the removal of a portion of the base of the skull, as far as the foramen ovale, have been practised by *E. Doyen, Cushing* and *Lexer.* I think these methods valuable when we have to deal, at the time of the extirpation of the ganglion, with neoplasmata of the middle fossa and also for the ligation of the trunk of the middle meningeal artery, as we shall see later on when dealing with injuries. *Cushing* and *Lexer* fashion their temporal flaps lower and sacrifice the bone. If this be preserved, a slight, barely visible scar will remain.

An example of neoplasm of the *Gasserian* ganglion follows.

OBSERVATION IX, 1

Sarcoma of the Base of the Skull that had Grown Into the Gasserian Ganglion. Extirpation of the Ganglion, Followed by the Disappearance of the Severe Symptoms. Death Fifteen Months Later.

The patient, forty-eight years of age, noticed the first symptoms of her trouble in the beginning of February, 1906. They commenced with a dull sensation and roaring in the head. From April to September the pains were localized over the right eye and extended from here to the root of the nose and into the ear. The patient also had a sensation as if the root of her tongue were thickened. By the end of September the pains, which were almost continuous though not paroxysmal, were radiating into the teeth and into the back of her head. The severe toothache caused the patient to consult a dentist, who at that time discovered an enlargement of the glands in the region of both angles of the lower jaw. A great quantity of mucus mixed with pus was discharging from both nostrils; this was more

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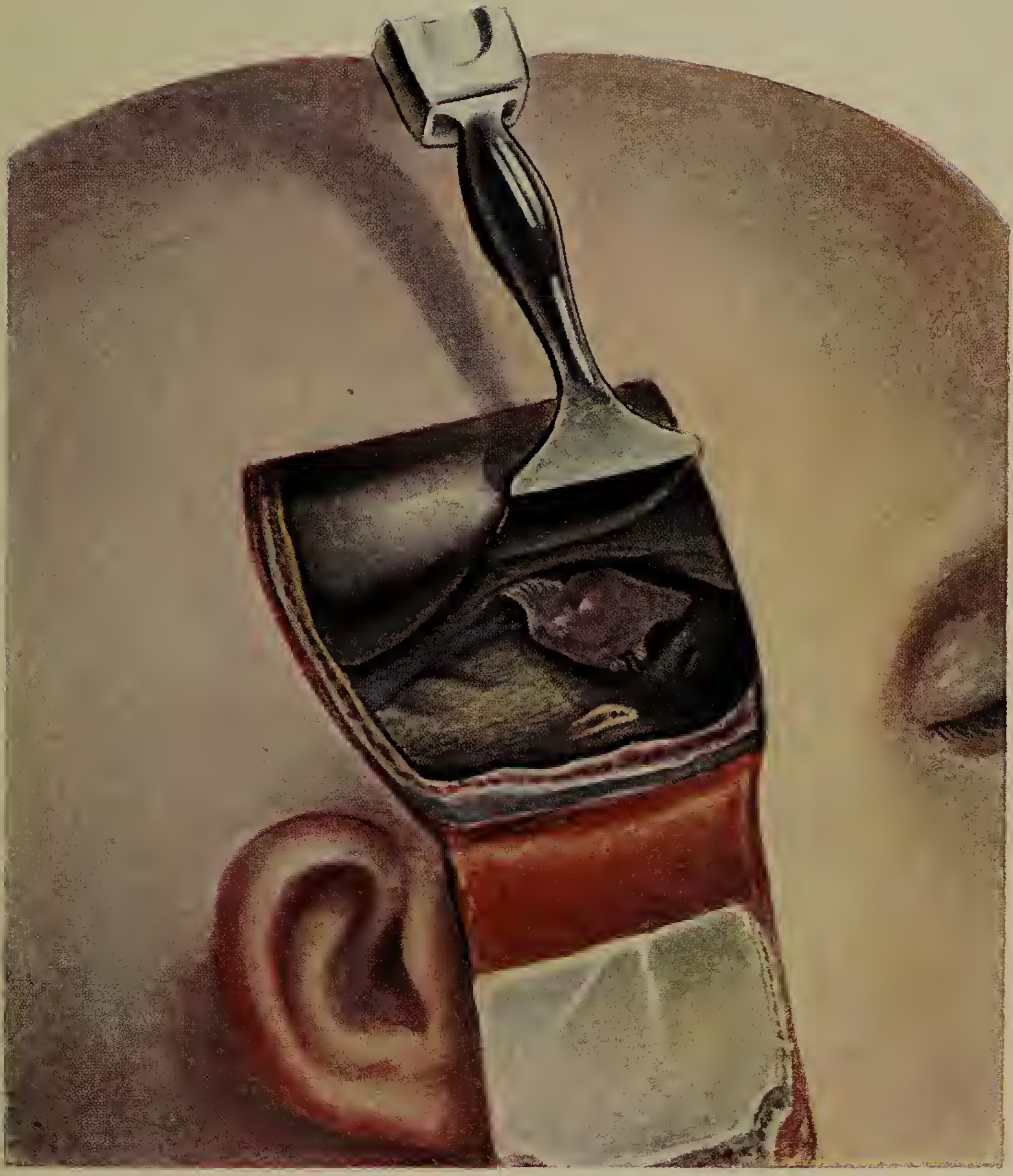
[1] *Hutchinson, Jr.,* "The Surgical Treatment of Facial Neuralgia." London, 1905.



Rebman Company, New York

marked on the right side. *H. Oppenheim* saw the patient at the end of September, and he was then of the opinion that the case was not one of pure neuralgia.

In the beginning of October, 1906, the patient sought relief at the Sanitarium of *Dr. Staehly,* in Bad Godesberg. *Dr. Staehly's* report of the condition of the patient, dated October 24th, showed the following objective findings: sensitiveness in the 1st and 2d, and paræsthesias in the 3d branch of the trigeminus (lingualis). Abducens paresis on the right. Disturbances of the oculomotorius on the same side (irritation)—hence differences in the pupils, right<left. Disturbances of the right opticus (irritation, glittering). Muco-purulent discharge from the nose. *Dr. Staehly* excluded genuine neuralgia and made a diagnosis of focal disease of the base of the brain in the right middle fossa of the skull, somewhat anterior to the *Gasserian* ganglion. He also thought that the process was either a malignant condition or an abscess. Lues could not be excluded; there was a hereditary predisposition to tuberculosis.

In the beginning of November, 1906, the patient was admitted to the private clinic of *Dr. Jansen.* A joint consultation (November 7th), in which *Professor Oppenheim* and myself were participants, convinced us of an affection of the 3d branch of the trigeminus. The muscles of mastication of the right side were weaker than those of the opposite side. The lower jaw, however, did not show any deviation when the patient opened her mouth. The sense of taste was not affected. There was a hyporeflexia of the right cornea and tachycardia (pulse, 120). *Dr. Jansen* thought the discharge came from the sphenoidal cavities. He, therefore, opened the right sphenoidal fossa through the posterior ethmoid cells. The mucous membrane was here jellylike and much swollen. A glandular pocket, the size of a pigeon's egg, was removed from the right side. The microscopic examination showed a large-celled round-cell sarcoma with mucinous changes.

In the further course of the disease, the subjective complaints were aggravated—the patient complained of excruciating pains in the upper and lower jaw as well as in the right half of the tongue. An incessant burning raged in her mouth, and she had the sensation as if a cautery iron were there. Pains commenced now in the upper maxilla as well. Whenever the patient slept on the right side she perceived upon awakening pain in the back of the head. There also existed a weakness of the right temporal muscle and a paralysis of the right pterygoideus externus. The right palpebral fissure was somewhat narrower than the left. *Oppenheim* ascribed the contraction of the right pupil to the action of the sympathetic nerve. The other branches of the oculomotorius were free and the ophthalmoscopic examination normal. This was associated with a flow of saliva from the right angle of the mouth and lachrymation of the eyes. The X-ray examination was negative.

Since the tachycardia became aggravated (pulse, 152), the left velum palati paretic, and the right bulbus prominent, and, furthermore, since the pains became almost intolerable, I made a diagnosis of tumor of the middle fossa of the skull, and subjected the patient, on the 17th of December, to an operation.

The method of operating corresponded essentially to the one described above (compare Plate XLII). The dura mater could be detached from the ganglion and branches with facility. This was done bluntly and no morbid parts were found attached to it. Since the neoplasm embraced the visible lateral section of the *Gasserian* ganglion on the one hand, and on the other invaded the base of the skull in a number of places, so that its radical extirpation was seemingly out of the question, I severed the trunk of the trigeminus in an apparently healthy portion; separated the entire ganglion from the underlying surface of bone with the raspatory without leaving any tumor remnants behind, and finally cut the 2d and 3d branch after they had been bluntly isolated, close to the foramen rotundum and ovale. This concluded the removal of the accessible portion of the tumor. A drain was introduced into the depth of the wound, and the field of operation exactly co-apted with sutures.

The patient withstood the operation, which lasted two hours, very well. The loss of blood was slight, and the woman was able to sit up in bed on the evening of the day of the operation. The drain was removed on the 22d of December. Until the 29th of that month, clear cerebro-spinal fluid drained from the small opening in the wound, after which date it ceased. On the 31st of December, the wound was entirely healed. Lancinating pains were perceived by the patient, in the head, until the 7th of January, after which date they recurred no more.

On the day the patient left the hospital (January 10, 1907) her lower jaw still deviated when she opened her mouth, but to no greater extent than before. The examination made by *H. Oppenheim* disclosed a sensation of bluntness in the region of the right side of the nose, cheek, and forehead—a little over the parieto-auricular line posteriorly. Tactile anæsthesia extended to the middle line. The analgesia of the skin of the head extended exactly to the parieto-auricular line, and of the face to the middle line. In the region of the cheek, it extended backward to a line that ran downward behind the zygoma of the superior maxilla. On the other hand, needle-pricks on the mucous membrane of the lower lip were perceived by the patient fairly over the median line (not very painful, however). She would then respond with reflex motions. The bulb was completely anæsthetic.

Mr. v. Hansemann sent in the following report of the histologic findings: "Numerous ganglion cells are to be found in a portion of fairly firm connective tissue that had undergone hyaline transformation. No pathologic changes are discernible in the former. However, in numerous places, showing inflammatory infiltrations of the connective tissue, the ganglion cells are destroyed. In isolated places, the entire structure is changed to such an extent that the characteristics of a nerve-ganglion are no longer recognizable. In such places we find a decided neoplasmic structure which is composed of fair-sized cells with vesicular nuclei. The cells are generously surrounded with intracellular substance, and this connects them with one another as well as with the underlying and surrounding connective tissue. In the centre of such tumor-masses, mucoid degeneration is present in which the tumor-cells have mainly perished. In comparison with the total extent of the ganglion these accumulations of tumor-cells are small and recognizable only upon microscopic examination. We, therefore, find that we are dealing with a sarcoma that has invaded the *Gasserian* ganglion, but whether it originated in it, cannot be asserted with certainty. The inflammatory and degenerative processes are to be looked upon as secondary conditions. It is our opinion that the tumor, having originated elsewhere, has subsequently invaded the *Gasserian* ganglion. The point of origin of the neoplasm cannot be ascertained from the specimen furnished."

Three months after the operation, the patient gained ten pounds. Outside of transitory pains in the right eyeball, her general condition was good. These pains yielded to Roentgenotherapy. Of the further course of the disease, I am informed that during the year 1907 the patient was able to move about without aid and evidently enjoyed life and took great interest in the daily affairs. She died on the 21st of March, 1908, fifteen months after the operation. I received no information as to her status in the last months of her life.

Prognosis in Extirpation of Neoplasmata of the Brain

While extirpation of tumors of the brain may show a whole series of brilliant results, it must be admitted that, taking the matter as a whole, the prognosis is still not very satisfactory. It is too frequently the case that the necessary tremendous surgical attack is out of proportion with the age of the patient and his weakened body. Death from shock is, for that reason, not of infrequent occurrence. The results in this respect have, since the introduction of the method of operating in two stages, considerably improved. And I wish to emphasize here once more the great danger of cerebral punctures and to recall the aggravation of the symptoms following them and the consequent bad influence on the prognosis (compare Observation V, 1, Vol. II, p. 616, and Vol. I, p. 231).

Dangers of Operation

The great danger of surgical intervention (of more frequent occurrence in the past than at present) is the *meningitis traumatica* or *septica,* and, with reference to it, the entire responsibility rests with the surgeon. Such a meningitis should be guarded against. This statement, of course, applies not only to operations for neoplasmata, but to all aseptic operations upon the brain, as for instance, in cases of epilepsy where the cerebrum is widely exposed, and where a flap, 9 to 10 cm. high and 6 to 8 cm. wide, has to be trephined. Up to the present time, three hundred and thirty-one of such extensive operations on the brain have been performed in Berlin by the writer. The greater number of these patients have died, to be sure, but not a single one has perished as a result of septic meningitis. Meningitis, as a rule, is characterized by so distinct a complexus of symptoms that, in the few cases in which we were not able to perform an autopsy, they could be clinically excluded. At the autopsy table not a single instance of septic meningitis has ever been found. Our Prosector, *Professor Oestreich,* will corroborate this statement.

In this fact, which is very satisfactory and encouraging to the surgeon we find justification for surgical interventions. I have entered into the lateral ventricle three times (compare Observation I, 12, Vol. II, p. 368); recently in a similar case in a girl ten years of age (also Observation IV, 1, Vol II, p. 590); the fourth ventricle was laid open wide in another instance (compare Observation VII, 12, Vol. II, p. 771). All four patients recovered. As is well known, the continuous drainage of liquor, saturating the bandages in the field of operation, is difficult to keep in an aseptic condition; yet this is possible to accomplish. But it requires extraordinary care not only on the part of the surgeon, but also on the part of his assistants and nurses. One must feel that one can rely on every one coming in contact with the patient. While my experience proves that septic infection and meningitis may certainly be avoided, there are many other dangers to cope with, after the collapse of the patient has been overcome.

In the first place, we must mention *pneumonia.* This complication is especially likely to occur in all diseased conditions of the brain which are complicated by disturbances of deglutition. The danger in these instances does not rest with the aspiration of food particles and liquids into the air-passages. This can be avoided by careful feeding and, if necessary, by resorting to rectal alimentation. The real danger in these cases is the aspiration of decomposed oral secretions which are always present for a few days after severe operations. Despite the most scrupulous cleanliness the decomposition cannot always be subdued, on account of the asthenic state of the patient.

Another danger is found in *hyperthermia* with acceleration of the pulse, which have frequently been seen in cases of operation upon the cerebellum or in its immediate vicinity, and which have continued for a considerable period with or without drainage of liquor. They weakened the patient extremely.

The danger of softening of the brain has been pointed out in Volume I.

In instances where the tumor has, by its growth, permanently destroyed certain portions of the brain, the recovery after a successful operation can only be partial. It should therefore be our aim to get the patient to the operating table as early as possible. In such cases, the general practitioner may give us invaluable aid by referring the patient to the experienced neurologist or surgeon upon the earliest discovery of morbid symptoms. This question should especially interest the ophthalmologist because people afflicted with visual disturbances naturally first consult the eye specialist, and not the neurologist or the surgeon.

The earlier we diagnose and locate the site of the neoplasm, the more favorable are the prospects of benefiting the patient by an operation. The usual practice of administering mercury and iodide is by no means a harmless one, because not infrequently the proper time for an operation is passed by and the chances in favor of the patient are thereby very much reduced or perhaps annulled. We must also constantly keep in mind that the œdema in the vicinity of neoplasmata of a non-specific nature may be absorbed under the influence of these drugs, and thereby cause a distinct recession of the symptoms, and, consequently, an improvement in his general condition without having the slightest influence on the tumor itself. Such improvements not infrequently create false hopes, not only in the patient, but in the attending physician as well, as a result of which, operation is postponed until a sudden aggravation in the condition of the patient forces the surgeon to interfere at a time when the conditions are by far more unfavorable. Furthermore, operative intervention may at such times be entirely out of the question. I have seen a number of patients die as a result of such procrastination.

Despite all that has been said, we must not feel discouraged. It takes a high degree of self-possession and stamina on the part of the surgeon to grasp the knife again after a series of discouraging operative failures, in the hope of seeing a successful outcome in the next operation. The day when the contention of *E. v. Bergmann* that only neoplasmata of the senso-motor region are amenable to surgical intervention was held to be an iron-clad rule, is no longer. Yet a great deal remains to be done. And, is it not a fact that other branches of the healing art that have been won over from internal medicine to surgery, have, in the beginning, yielded poor results and have become better and better through tireless effort and labor? Let us for instance recall the time when conditions, known now in their true light, were looked upon as perityphlitis. This, of course, is only a simple example in comparison with the serious nature of the work in question. If we now couple what has been said with the extreme difficulties encountered in making a local diagnosis, we must admit that despite all, the progress made in the last few years in this difficult branch has been little short of marvellous. An example of this is the positive diagnosis of tumor of the acusticus which has been made possible only in the last few years, although *Virchow* described this condition in his classical work on neoplasmata.

If we now reflect and take cognizance of the fact that the inevitable fate of the patient afflicted with brain tumor is death, to say nothing of the indescribable mental and physical tortures (think of the blindness alone!) he has to endure before death relieves him of his agony, it will at once be seen that it is our duty to come to his rescue and hold out to him the only hope offered to him by an operation, for every patient cured by surgical means is wrenched from the clasp of certain death.

We should also remember that in all cases of heightened intracranial pressure sudden death may supervene before it is at all possible to accomplish decompression by trephining. For an example: One of our leading neurologists made a diagnosis of a neoplasm of the thalamus opticus in the case of a woman twenty-six years of age, and, since a radical extirpation was apparently impossible, operation was not considered at all. During an observation of six months the patient was suffering exceedingly, acute cerebral compression suddenly set in, and, before she could be brought to a surgical clinic, death supervened from paralysis of the nuclei of the vagi. A decompression operation in this instance would, in all probability, have led to an amelioration of the symptoms, and the life of the patient might have been prolonged.

In selecting our cases for surgical intervention we must separate those cases that are amenable to surgical treatment from those in which a complete eradication of the trouble seems impossible. A fertile field is here open to the neurologist, whose labors, judging by the progress made in the last years, will be well rewarded by further refinement in diagnosis and by the solution of intricate and unsolved problems. However, until that time, a great many trepanations will necessarily have to be performed to find whether the condition had progressed beyond hope of a radical cure. But, even in these instances, our efforts have not been in vain, because decompression-trephining is a justified, palliative operation.

The prognosis also varies with the nature of the neoplasm. The most unfavorable tumor is the diffuse glioma which is not encapsulated, and which by its extension, invades important structures contiguous to it, transforming and destroying them. Microscopic examination of these gliomata shows that they are not limited, i.e., there is no dividing line between the normal cerebral substance and the structure of the neoplasm—a very unfavorable state of affairs with reference to operative intervention. The day may not be distant when a diagnosis of infiltrating glioma may be made with a certain degree of probability, in which event, these cases will, of course, be relegated to the class of inoperable conditions, because, even though these tumors are located in the cortex, their intimate union with the surrounding structures will not permit a radical removal. If the great percentage of those inoperable conditions be deducted, the general operative prognosis would be considerably bettered.

Tumors which offer the best prognosis and which may be removed with certainty, are those that are encapsulated. Of these again, the easiest to remove are the cortical neoplasmata that spring from the cerebral membranes and extend into the brain substance. But even in these cases, the prognosis is encumbered by the fact that occasionally plugs of the original tumor grow into the brain substance and that, regardless of the most careful operating, remnants will remain that will give rise to recurrences (compare Observation IV, 1, Vol. II, p. 590).

The danger of the operation varies with the seat of the neoplasm. I consider it of the utmost importance to give an entirely true picture of my experiences. Only such statistics of any surgeon are of use for our theme as mirror conditions as they are, without digressing an atom one way or the other. Statistics made up of the experiences of a number of observers are usually unreliable for the reason that there are surgeons who have had few and perhaps unsatisfactory results from their operations, and hence do not feel inclined to bring them to general notice.

For the following statistical data, I am indebted to my assistants, *Physician in Chief Dr. E. Heymann* and *Dr. Hartig.*

There was a total of 109 cases operated on for neoplasmata of the brain substance (both cerebrum and cerebellum). Of these operations, 19 were performed in one sitting. Of the remaining 90 patients operated on in two stages, 18 died after the first sitting, before the dura had been opened into. This leaves a total of 72 cases operated on in two stages.

Of those operated on in one stage, 66⅔% died; of those in two stages, 20.85%. The mortality, according to the regions operated upon (leaving entirely out of consideration the age and the general condition of the patient as well as the duration of the disease), was as follows: frontal brain, 43.5%, central region, 27.1%, temporal lobe and island, 26.6%, parietal lobe, 32.8%, occipital lobe, 25%, and cerebellar hemispheres, 53.7%.

The histologic structure of 81 neoplasmata examined with the microscope was as follows: 9 solitary tubercles, 21 gliomata, 6 gliosarcomata, 4 endotheliomata, 11 fibrosarcomata, 8 neurofibromata, 15 sarcomata, 4 angiomata, 2 metastatic carcinomata, and 1 metastatic hypernephroma.

Neoplasmata of the cerebello-pontine-angle offer by far the worst prognosis, and I, therefore, shall speak of them separately.

Of 24 patients operated upon, only 4 were cured; a man, thirty-four years of age, and three women, thirty, forty-four, and forty-nine years of age respectively. Of these, the last patient shows the longest freedom from trouble after the operation—since the 12th of September, 1908. The prognosis of these tumors would undoubtedly have been far better had the patients come earlier to the operating table. In not a few of our cases, the beginning of the trouble was traced as far back as six to eight years, and, from the characteristic symptomatology of these cases, a correct diagnosis could have undoubtedly been made at that time. Most of my cases of such neoplasmata that were pronounced inoperable showed at the autopsy that the tumors were not amenable to surgical treatment on account of their extension into the middle fossa of the skull, and because of their penetration into the substance of the petrous portion of the temporal bone, and also on account of compression, flattening, and excavation of the pons and medulla oblongata. A surgical procedure in such cases would have been so enormous, that the already afflicted respiratory centre would, during the severe operation, have entirely refused.

Intracranial Suppurations

To make a diagnosis of abscess of the brain, the etiology plays the most important rôle. If no primary point of infection is found, the diagnosis will at best be rendered very uncertain. Whether such a condition as idiopathic abscess of the brain exists at all, is very doubtful; at any rate, compared with the other forms, it is extremely rare.

Traumatic Abscesses of the Brain

Every injury of the brain which is complicated by an infection of the wound may give rise to cerebral abscess. This is true for all portions of the cerebrum. We designate

Acute Traumatic Abscess of the Brain

all those instances which follow immediately upon the infliction of an injury. For instance, the collections of pus following the penetration of a foreign body or compound fractures of the skull.

Since the coverings of the brain in these cases are also involved in the injury as well as in the infection following it, there is always a concomitant meningitis. If the suppuration progresses in the meshes of the arachnoid and the pia, a diffuse suppurative leptomeningitis results, that, without exception, leads to the death of the patient. In other cases again, the inflammation flared up by the infection of the soft membranes of the brain limits itself to the immediate vicinity of the cerebral injury; and, in such cases, a more or less circumscribed focus of suppuration within the cortical substance of the brain and in its immediate vicinity will result—cerebral abscess.

Acute traumatic cortical abscesses are usually situated in the immediate vicinity of the wound in the region of the contused brain substance. They represent, to a certain measure, a retention of pus within a pocket of the wound, the egress of which may be hindered by a fragment of bone. Such wounds have, as a rule, a septic appearance, and pus is frequently seen issuing from between the lips of the wound. This is usually associated with symptoms of meningeal irritation and manifestations of focal irritation and paralyses that depend upon the respective section of the cortex involved. The study of the symptomatology of these cases is the same as that occasioned by neoplasmata of the respective cerebral regions, to the chapter on which the reader is referred. The so-called *early abscesses* cannot, as a rule, be distinguished from traumatic suppurative meningitis. While suppurative leptomeningitis develops very soon after the injury has been inflicted and occasions morbid manifestations corresponding to its site and extent, the development of an abscess requires, at any rate, a few days or, perhaps, from one to two weeks. The reason why a deathly leptomeningitis purulenta develops in some cases and in other cases again, an abscess develops, is as yet unknown.

Two examples of acute traumatic abscess of the brain follow.

OBSERVATION X, 1

Blade of Knife Remaining in the Left Temporal Region for Thirteen Days without Causing Marked Disturbances and then Leading to the Formation of a Large Cerebral Abscess that Broke into the Lateral Ventricle. Sudden Death from Flooding of the Fourth Ventricle with Pus.

On the night of the 26-27th of December, 1897, while on his way home with a friend, the patient, a laborer twenty-eight years of age, was without cause attacked by an individual following him. He received a blow on the forehead, which he believed to have been inflicted with a billy or a bat. In spite of the considerable hemorrhage that followed he did not feel weak, and he proceeded quietly toward home. He was dressed by a physician on the following day. He remained in the care of his lodge physician for thirteen days, during which time he was perfectly clear mentally, and complained only of increasing headaches. His appetite finally became bad. The physician ordered certain powders for him for the relief of a gastric disturbance from which he was suffering. The left half of his face had been (in the beginning) somewhat swollen, but the wound healed within eight days without disturbances. The patient did not improve, however. Becoming worse, he was sent to the Hospital of Altona on the 9th of January, 1898.

The patient, a powerful, well nourished, somewhat pallid man, arrived at that institution on foot. His heart and lungs were normal. A red, vertical scar, about 1½ cm. in length and sensitive to the touch, was found over his left eye. The skin covering the bone, which was also apparently injured, could not be satisfactorily moved. The patient complained of headaches in the region of the scar, but percussion of the head caused no pain. The eye and ear on that side were normal and paralysis of the extremities did not exist. His gait and speech were normal, although he spoke somewhat hesitatingly. Outside of the complaint that within the last few days he had noticed some weakness of his memory, nothing of importance was elicited upon further questioning him. He was admitted to the hospital at three o'clock in the afternoon and ordered to bed. He partook of dinner, and drank coffee at four o'clock. His pulse was regular, and his axillary temperature 37.4° C.

About five o'clock in the afternoon of the same day, the patient suddenly became very restless, his temperature rapidly rose to 40.6° C., he became delirious, and at six o'clock he was unconscious. His respiration became stertorous, his pulse small and very rapid. At ten minutes after six, he was dead.

By order of court, a post-mortem examination was held (11th of January) at the hospital, by *Geheimrat Wallichs* and *Dr. Fischer*. The most important data found in the protocol of that examination follow:

A narrow scar in the skin of the left forehead, about 1½ cm. in length, was found running a little to the left of the median line of the eyebrow and close over it, obliquely from without downward, inward, and upward. There was a rough, somewhat deepened place on the left frontal bone about 1 cm. in length which corresponded to the direction of the scar of the skin.

About three tablespoonsful of green pus were evacuated during the removal of the vault of the cranium, which was of

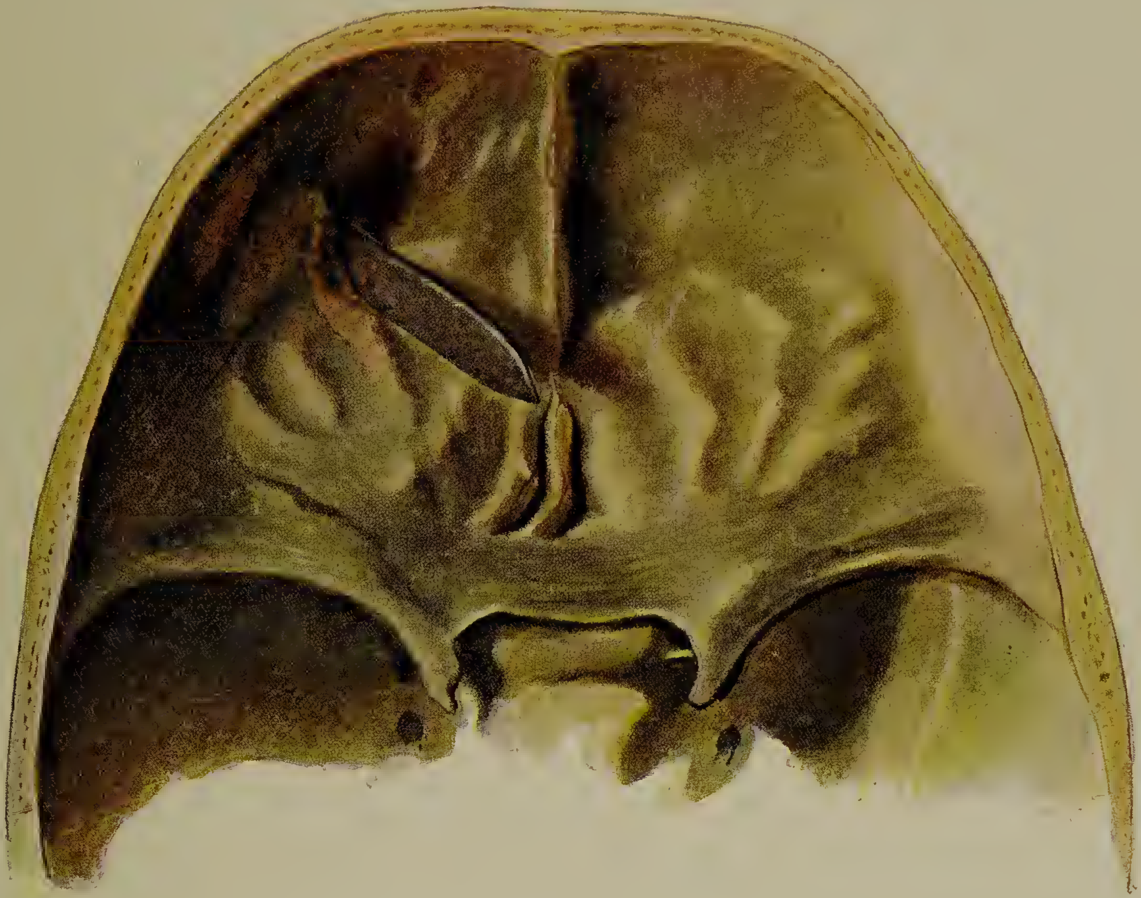


Fig. a.

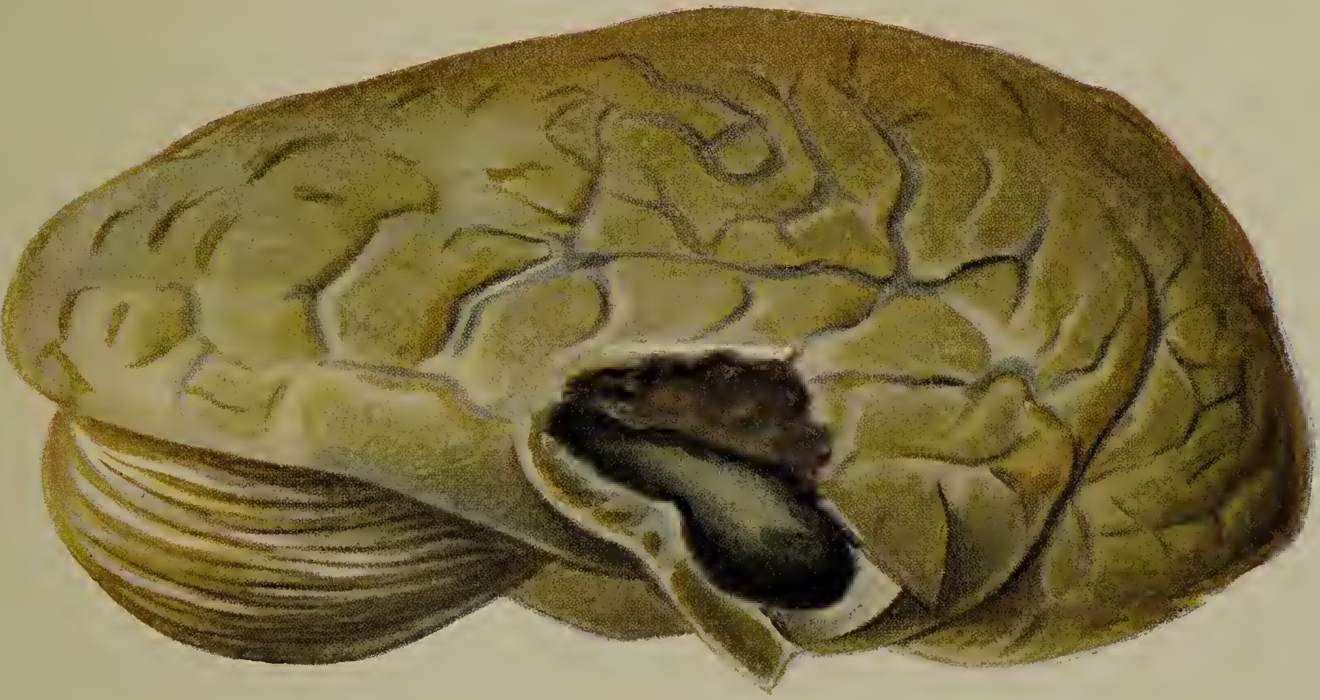


Fig. b.

normal shape and dimensions. Some semifluid and semicoagulated blood was found in the sinus longitudinalis. The dura mater was smooth and its vessels slightly turgid. The soft covering of the brain was found cloudy on the left side, and streaks of pus were visible along the congested vessels.

Inspection of the anterior fossa of the skull, above the roof of the orbit, at the place corresponding to the osseous scar disclosed a part of the blade of a knife firmly imbedded in the substance of the bone (see Plate XLIII, Fig. a). The brain was then carefully removed. A pus cavity, the size of a hen's egg, with fairly smooth walls, into which the blade of the knife was projecting was found in the left frontal lobe. The blade was firmly wedged in the perforated bone; it was 4 cm. long and 1 cm. in width, and it tapered off toward its point; it occupied a somewhat oblique position, and its point extended almost to the median line.

The pus had broken through the left lateral ventricle, and a little of it was also found in the right lateral ventricle. The cerebral substance was soft and not very vascular. The soft cerebral membrane covering the base of the brain was smeared with pus and also cloudy.

Plate XLIII, Fig. a, depicts the base of the skull together with the knife. The handle of the knife, taken from the assailant when he was arrested, contained a small portion of the blade, the line of fracture of which fitted exactly into the wound of the frontal bone.

The autopsy, therefore, disclosed a cerebral abscess which had developed around the blade of the knife that was imbedded in the left frontal brain for a period of thirteen days. Neither the severe injury nor the large abscess caused morbid manifestations of any degree. The patient was up and around during the entire time and he walked into the hospital. The death of the patient, that set in about three hours after his admission to the hospital, was caused by the breaking of the abscess into the left lateral ventricle. From here, the third ventricle, the right lateral ventricle, and through the aquæductus *Sylvii* the fourth ventricle, were flooded with pus. The immediate cause of death was paralysis of the vital centres of the floor of the fourth ventricle.

Had the patient been admitted to the hospital earlier, a glance through the fluoroscope would at once have shown the blade of the knife in the interior of the skull. During the autopsy nothing of the blade was seen on the surface, because the wound had completely cicatrized over it and the knife had broken at a point a little below the surface of the skull. Had the blade been discovered earlier it would have been an easy matter to trephine the frontal region, remove the blade, and drain the abscess. There is a great probability that the patient could have been saved by such a procedure. That this statement is justified, is proved by the following case.

OBSERVATION X, 2

Penetration of the Point of an Umbrella Into the Left Orbital Cavity and Into the Frontal Brain. Very Large Ichorous Abscess. Cure After Enucleation of the Eyeball which was Destroyed by Suppuration. Removal of Splinters of Bone, and Drainage of the Abscess Cavity.

A farmer, twenty-six years of age, was admitted to the hospital suffering from a panophthalmia of the right eye. Fourteen days prior to his admission to the hospital he had been a participant in a fight during which he was struck in the right eye with the point of an umbrella. Until a few days ago outside of having some headaches he felt perfectly well. He walked into the Hospital of Altona after sojourning for four hours on a steamer from the Elbufer of Hanover. He was a powerful man, and outside of headaches he felt tolerably well. His axillary temperature was 38.4° C. Focal manifestations did not exist.

Close above the eyeball which had been destroyed by suppuration a transverse tear, covered with a smeary deposit, was found in the conjunctiva bulbi. Upon introducing my finger into it, splinters of bone were discovered in the depth of the wound. The eye was enucleated, after which a number of pieces of bone from the roof of the orbit were removed with a pair of dressing forceps with ease. This was immediately followed by the evacuation of malodorous pus that was intermingled with particles of brain tissue. The index finger advanced through the opening in the roof of the orbit (without meeting any resistance) and into the cavity of the skull. The abscess cavity was so deep that I could not reach all its recesses. The enormous abscess in the frontal lobe of the brain extended backward. After enlarging the cleft in the bone, the pus was carefully wiped out of the cerebral abscess, and a drain, the thickness of a finger and surrounded with iodoform gauze, was introduced loosely. For the first fortnight the drainage was very profuse, but it soon became less, and seven weeks after the operation the patient was discharged from the hospital. This was in September, 1893.

I saw the patient a year later in Stade, during the trial at court. He was perfectly well with the exception of the loss of his eye. He continued at his previous avocation, that of a farm hand, and he complained neither of paralyses, anæsthesias, nor morbid manifestations of any nature. His mental functions were also entirely unaffected. I received a letter from him eight years after the accident (about the end of 1901) in which he wrote of his excellent physical condition

This observation teaches that even large accumulations of pus within the brain will give rise to comparatively few symptoms, and that with proper treatment the patient may be completely cured.

Chronic Traumatic Abscesses of the Brain

Chronic traumatic abscesses may result from the same causes that give rise to the acute variety, or they may follow them. The latter occurs when the septic focus within the brain is rapidly walled off from the contiguous healthy structures. If the virulence of the infectious organism be low, or if the power of resistance of the surrounding structures be great, the clinical manifestations will be mild, and the course of the disease less acute. Compound fractures and foreign bodies may in this manner lead to chronic abscesses. Chronic suppurative processes of the bones of the skull, resulting from trauma, may finally lead to abscess formation in the brain by infecting its substance through the extension of the invading microorganism by means of a progressive venous thrombosis. In cases of decided chronicity of the process (abscesses were known to exist for many years), exacerbations will frequently occur. They are characterized by inflammatory manifestations that lead, every time they set in, to an increase in the size of the abscess. Although chronic abscesses are, as a rule, encapsulated by a layer of tissue known as the *pyogenic membrane,* acute exacerbations may soften that membrane, perforate it, and flood the ventricles of the arachnoid space with pus and thus cause the death of the patient. Sudden disaster may also be wrought by an acute cerebral œdema. Early diagnosis and prompt evacuation of the pus alone can save the patient.

With reference to the *diagnosis of chronic traumatic abscesses of the brain,* a differentiation must be made between the symptoms caused by the injury proper, and the manifestations resulting from the development and the extension of the abscess. After the primary symptoms caused by contusion or concussion of the brain and the extravasation of blood have faded, there usually follows a period of months or even years during which the patient is only slightly disturbed or he feels perfectly well; this is the so-called latent period which is frequently accompanied (outside of symptoms of general cerebral compression), by late symptoms of cerebral abscess. It depends entirely on the functional importance of the cerebral territories involved, whether the disturbances set in early, late, or not at all. The focal symptomatology has been so thoroughly discussed in the preceding chapters, that I shall restrict myself to a few brief remarks on the question, in order to avoid unnecessary repetition. It is a remarkable fact, that large territories of the cerebral hemispheres may be melted away by the suppurative processes without the occurrence of the slightest symptom to indicate what is going on (compare both observations of acute cerebral abscess). Psychic disturbances have been noted to occur in suppurations of the frontal brain and also in abscess of the temporal lobe. In the latter instances the sexual sphere was principally affected.

The abscesses usually develop by degrees and increase in size under inflammatory manifestations and paroxysmal symptoms, while the patient is apparently well. The most important of these symptoms are: Headaches emanating from the scar; psychic depression, vertigo, nausea, occasional high tension and slow pulse, and finally, hyperthermia. It should be stated that cerebral abscesses may run an entirely afebrile course. This is especially the case in encapsulated abscesses that have not become absorbed.

Trepanation is Indicated

when a diagnosis of cerebral abscess has been made, and where there is sufficient reason to suspect the existence of suppurative processes within the cranium. The old dictum: *ubi pus, ibi evacua,* holds in these cases even better than in others, because the life of the patient in intracranial suppurations is always in imminent danger. The experienced eye will recognize, in the œdematous changes of the granulations of the wound, that may perchance persist, a sign of trouble lurking in the depths. The defect in the vault of the cranium should be made sufficiently large or widened correspondingly. The dura mater covering the abscess is frequently of a dirty or yellowish color. As a rule, pulsations are absent in the dura, but their presence does not signify that no abscess exists. This should be noted. I perform diagnostic aspirations only after the dural flap has been reflected, because with the dura intact, the pus may enter the arachnoid meshes through the puncture tract made with the aspirating cannula, and an infection of the meshes may follow. For technic, compare chapter: *Opening of Cerebral Abscesses,* Vol. I, pp. 103–107.

Outside of trauma cerebral abscesses are sometimes known to develop in connection with inflammatory processes and suppurations of the bones of the skull and the soft tissues covering them, as well as morbid diseases of the nose, the ears, and the accessory sinuses. We therefore recognize rhinogenous and otitic abscesses of the brain and those that develop in connection with caries and similar processes in the bones of the skull. For the sake of completeness, actinomycosis, cerebrospinal meningitis, and tuberculosis should also be mentioned as possible etiologic factors for cerebral abscess. As stated before, conglomerated solitary tubercles should, in accordance with the clinical manifestations they produce, be classified as brain tumors. However, if the tubercles break down and give rise to suppuration, a real encapsulated cerebral abscess may result (compare Observation V, 2, Vol. II, p. 631). Of course, these cases are to be separated from those foci of suppuration that develop in connection with tuberculosis of the bones of the skull. The latter belong to the class of carious bony processes mentioned above.

Extradural Traumatic Abscesses

The same causes that occasion abscess of the brain may be responsible for extradural collections of pus. No repetition is therefore necessary, and the following observation will suffice as an illustration.

OBSERVATION X, 3

Gunshot Wound of the Petrous Portion of the Temporal Bone. Extradural Abscess with Cerebral Manifestations. Wide Opening with the Trephine. Cure.

A merchant, thirty-two years of age, was assaulted on the 5th of June, 1905, and severely injured. The assailant inflicted a stab-wound on the right side of the neck that penetrated deeply, close to the carotid artery, and perforated the floor of the mouth and the soft palate. The patient tried to wrench the dagger from the hand of his assailant and during the struggle the tendons of the palm of his left hand were divided. A bullet from a revolver shattered the right half of his lower jaw, injured the cervical vertebræ and spinal cord, and travelled backward under the skin to the level of the spinous processes of the 5th and 6th vertebræ. The patient at once became paralyzed and was unable to move from the place. The second bullet destroyed the left organ of hearing, and entered the petrous portion of the temporal bone. For the further course of the spinal injuries compare that chapter with Observation XIV, 9.

Both bullets caused severe disturbances and were extracted. About the end of June, while the patient did not complain of any symptoms, his temperature suddenly rose to 40.3° C. This was accompanied by manifestations which pointed to an abscess of the brain. On the 8th of July, I widened the granulating wound in the region of the left ear, carried out the radical operation on the organ of hearing, and penetrated into the depths

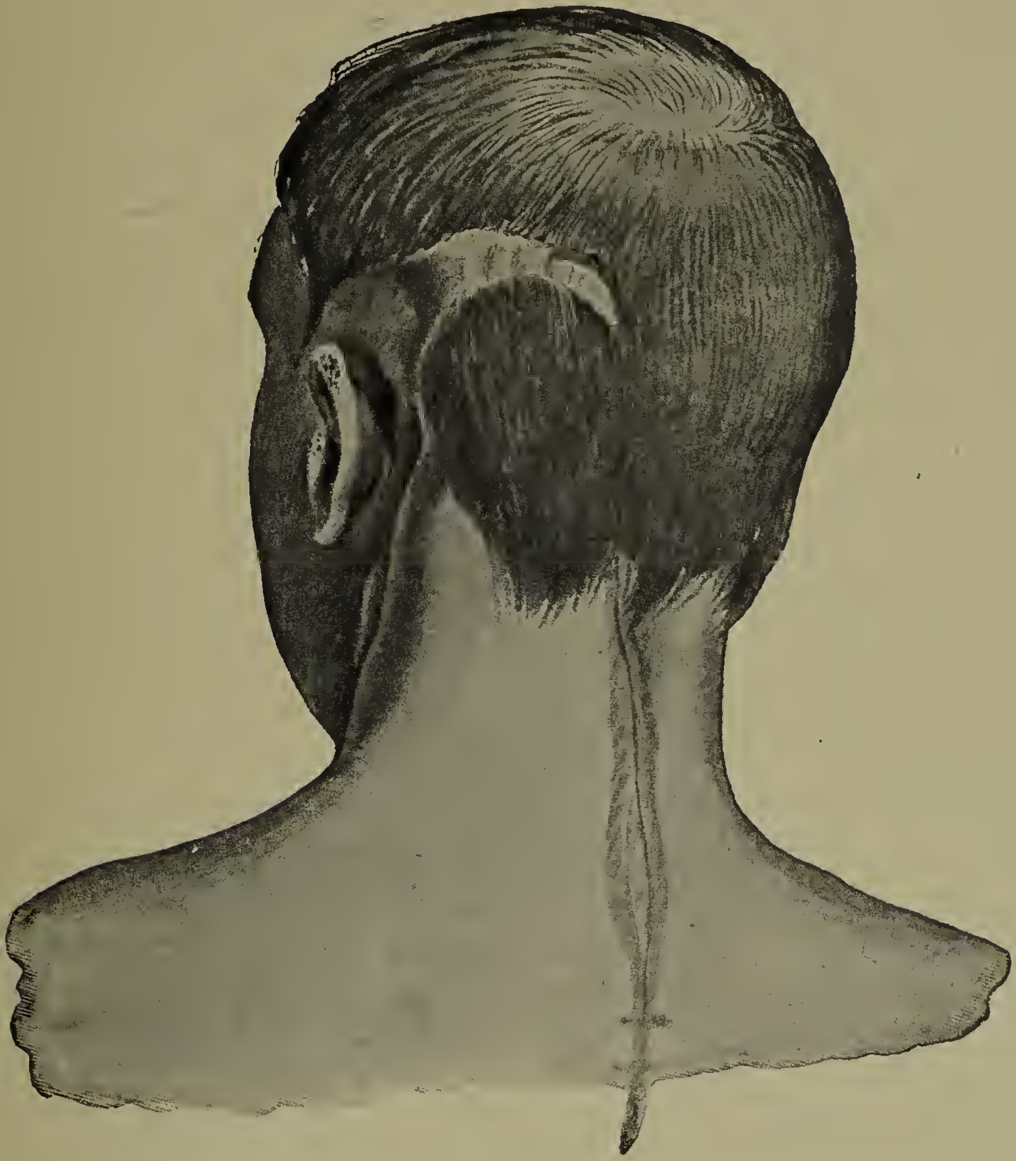


Fig. 146

on account of extensive suppurative granulations that extradurally infiltrated the petrous portion of the temporal bone. At the upper border and the posterior surface of the petrous portion of the temporal bone, the suppuration had extended very deeply. I was therefore obliged to excise a large flap of bone (see Fig. 146 above) in order to gain sufficient space to detach the dura from the petrous portion of the temporal bone, and remove all septic and infiltrated tissues and granulations in an entirely extradural manner. The large cavity of the wound was packed with iodoform gauze.

On the day following the operation, the temperature was normal, and the further course of the disease remained afebrile until the wound closed. The patient left his bed eighteen days after the operation, and since the resulting *Brown-Séquard's* paralysis had also considerably improved, he was able after a little while to walk to the operating room, supported by a nurse, to have his dressings changed. Despite a certain weakness that remained, the patient could use his right lower limb to such an extent that about the middle of August he climbed stairs with slight support. In the following months numerous small sequestra were thrown off, after which the wound in the skull remained closed.

Otitic Abscesses of the Brain

Cerebral abscesses that owe their existence to suppurative processes of the middle ear are of special significance. They frequently result from chronic otitic suppurations, especially those forms occurring in connection with cholesteatoma, and as a consequence of acute inflammatory processes of suppuration. A further cause is found in those diseases that lead to necrosis of the bones surrounding the organ of hearing, and, therefore, in osteomyelitis. The location of the abscess of the brain in these cases depends entirely upon the seat of the sequestrum in the petrous portion of the temporal bone, and upon the line of travel of the pus from the middle ear. It may be laid down as a rule, that the temporal lobe usually becomes infected through the upper part of the tympanic cavity or from the roof of the antrum mastoideum, while infection of the cerebellum usually proceeds from the mastoid process of the temporal bone. However, suppuration in the posterior fossa of the skull may also be occasioned through the labyrinth.

The clinical picture is frequently so indistinct, that it is difficult to say whether we are dealing with a meningitis or a cerebral abscess. Lumbar puncture will occasionally (not always) yield a cloudy, purulent fluid in cases of meningitis, while in abscess of the brain, the liquor will remain clear. Normal temperature, absence of febrile manifestations, and somewhat slow pulse of high tension, speak for abscess; rigidity of the neck for meningitis.

It is often doubtful whether the suppurative focus is extradural or within the brain, and finally whether the cerebral abscess is located in the temporal lobe or within the cerebellum. Middle ear suppurations will cause further complications after they have affected the antrum mastoideum and the cells of the mastoid process of the temporal bone, by infecting the fossa sigmoidea, and thus lead to septic thrombosis of the sinus sigmoideus. At first headaches and rises of temperature may be the only symptoms of this severe disease until repeated chills produce the typical picture of pyæmia, leaving no room for doubt as to the correctness of the diagnosis, but then, as a rule, it is unfortunately too late.

However, if the case be one difficult to diagnose, and if the symptoms point to a severe infectious process within the cranial cavity, it is at all times advisable not to delay an operation. Good operating can never hurt a patient, while procrastination is dangerous and may cost his life.

I open all otitic abscesses of the brain by *E. v. Bergmann's* incision which encircles the upper border of the auricle at a considerable distance, after which the mastoid process is chiselled open and the radical operation continued. This method affords ample room to reach the posterior surface of the petrous portion of the temporal bone nearly to the median line, should suppurative processes require such exposure. Should the abscess spread from this region and also infect the point of the pyramid, or be located to the front of the latter, it is only necessary to continue *v. Bergmann's* incision in that direction. This greatly facilitates the exposure. Most surgeons refrain from preserving the bone in extensive suppurative processes.

We now reach the region that I have utilized in the extirpation of the *Gasserian* ganglion. This temporal method exposes the entire middle fossa of the skull—to the back and the upper border of the petrous portion of the temporal bone. In those cases in which I intend to preserve the bone, I am substituting for *v. Bergmann's* incision, a rectangular cut the base of which is directed upward and above the auricle (compare Plate

XLV). This method permits us, if necessary, to advance in any direction without sacrificing bone.

I shall cite further on a series of examples that will illustrate the conditions clearly.

Otitic Abscesses of the Temporal Lobe

result from suppurative conditions in the tympanic cavity which is very frequently the seat of carious processes. If the pus breaks through the tegmen tympani, or should necrosis of the bones supervene, the pus will collect on the upper surface of the petrous portion of the temporal bone, extradurally, and may lead to the formation of a temporal abscess. Abscesses of the temporal lobe are frequently situated close to the border of the occipital lobe. In this position, a form of amnesic aphasia, known as optic aphasia, will result. Plate XLIII, Fig. b, shows a typical temporal abscess in a man twenty-four years of age. This patient was admitted to the Augusta Hospital in a somnolent condition and soon after his reception died. The autopsy *(Professor Dr. Oestreich)* showed the cerebral gyri flat and the convexity as well as the under surface of the frontal and temporal lobes free from pus. Only the region of the pons, the chiasma, and the medulla oblongata disclosed a purulent infiltration of the arachnoid. The cerebral substance and the dura in the posterior and lateral portion of the right middle fossa of the skull were strongly adherent. After ablation of the dura, the anterior portion of the pyramid of the petrous portion of the temporal bone was seen to be very red, vascular and porous. The mucous membrane of the middle ear was extremely red and hemorrhagic. The bone in the region of the labyrinth was carious and of a yellow color. The cerebral substance in the region of the lowest convolution of the temporal lobe was œdematous, and harbored an abscess cavity the size of a hen's egg.

The arachnoid of the spinal cord was thoroughly infiltrated with pus, and the substance of the cord showed a slight redness and was moist. The internal organs showed nothing of importance except that the spleen was small.

Diagnosis: Purulent cerebro-spinal meningitis; cerebral abscesses.

The following observation gives an example of a healed abscess of the temporal lobe.

OBSERVATION X, 4

Suppuration of the Ear with Symptoms of General Cerebral Compression. Chiselling of the Mastoid Process of the Temporal Bone. Cerebral Puncture through the Exposed Dura, Negative. Continued Cerebral Pressure, Paraphasia, and Choked Disc on the Left Side. Opening of a Large Ichorous Abscess of the Temporal Lobe. Prolapsus of the Brain. Complete Cure for the Last Twelve Years.

A woman, thirty-six years of age, was suffering for twelve years with middle ear disease of the left side that had become much aggravated within the last fourteen days. Four days prior to her admission to the hospital, her evening temperature was 39.5° C., while in the morning it did not exceed 37.5° C. This was accompanied by marked headaches. Severe vomiting-spells were added to the existing symptomatology, and the woman was admitted to the Hospital of Altona, on the 24th of July, 1899. She created the impression of a very ill patient and complained of most excruciating pains in the whole head. Morning temperature, 36.5° C., pulse 56, full and of high tension.

Percussion of the head was painful only over the left mastoid. A malodorous pus discharged from the left ear, and an indescribable fetor issued from the mouth. The left facialis was paralyzed, the sensorium was free and there was no vomiting and no rigidity of the neck.

In my absence my first assistant proceeded to chisel open the mastoid in a typical manner, during which an ichorous pus, intermingled with necrotic particles of bone, was discharged. The dura mater, together with the sinus sigmoideus, were laid bare to an extent of a half dollar. Both of these structures appeared to be normal, and the somewhat tense dura showed distinct pulsations. Puncture of the brain was negative. During the operation an ichorous pus was discharged from the mouth of the patient.

On the following day the headaches were somewhat slighter, the pulse was 66, but still hard and tense, and the temperature was 37° C. The latter rose only twice (in the evening) during the entire period of observation; the first time, to 37.2° C., and the second time to 37.3° C. Vomiting set in again and was accompanied by a distinct paraphasia and a certain psychic disturbance—the attention of the patient could not be engaged. On the following day, distinct choked disc was found on the left side; on the right, the fundus oculi was practically normal. Since the paraphasia became more marked and the other symptoms were not influenced by the first operation, I thought of the possibility of an abscess in the left temporal lobe so deeply situated that it was not reached by the first puncture, and that the pus within it may have been so thick that it could not be aspirated.

I, therefore, operated again on the 26th of July, 1899; *v. Bergmann's* incision (see Fig. 45, Vol. I, p. 212, A B K M). The squamous portion of the temporal bone was exposed, and removed. The appearance of the exposed dura was not changed; it was very tense, and showed no pulsations. It was split transversely to an extent of 4 cm., and after protective tamponade of the subdural space (see Vol. I, page 104), and without preliminary puncture, the exposed portion of the temporal lobe was also divided near the base of the skull. An abscess cavity was discovered only after the scalpel had penetrated to a depth of 2 cm. The abscess was at least 4 cm. in diameter. It contained tenacious, stinking pus, from which streptococci, diplococci, and short as well as long bacilli were grown on culture media.

For four days after this operation the symptoms did not change; the high tension pulse still continued (50 to 60 beats per minute). Soon thereafter, however, the improvement was rapid and decided. On the 29th of July choked disc still persisted, but on the 2d of August it was receding, and the border of the papilla could at that time be distinctly recognized. About the middle of August the papillæ were equal on both sides. A cerebral prolapsus, the size of an apple, which had developed until that time receded again, so that about the middle of September it was completely gone. On the 16th of September the patient had gained five pounds and she was discharged from under our care. The paralysis of the facialis of the left side continued at that time unchanged, but in the following months it completely disappeared of its own accord (shown by an examination on April 6, 1900).

The diagnosis of cerebral abscess in this important case was made from the following symptoms: Headaches, high tension pulse, paraphasic disturbances, and choked disc. This symptomatology was added to the chronic suppurative otitis media during an acute exacerbation. Choked disc, the most important sign of increased cerebral pressure—occurs in cases of cerebral abscess on the side corresponding to the morbid focus.

The paraphasic disturbances were of great importance. They pointed to an involvement of the sensory centre of speech (*Wernicke*) (compare Fig. 85, p. 427); the seat of the abscess was therefore necessarily in the temporal lobe. Two days after the opening of the abscess of the brain (28th of July), the first satisfactory examination of the patient could be made. The power of understanding of speech was retained, but there was: Complete absence of the recollection of pictures, of the sound of her name, of her residence and of her present abode; there was also the appearance of entirely incorrect pictures of words, and also an absence of word pictures of objects shown to the patient. She described them with wrong expressions. Only occasionally a correct name was uttered by her when a certain object was held before her. While we were dealing in this instance with focal symptoms which mainly pointed to an involvement of the sensory centre of speech, there were also symptoms of general exhaustion and increased cerebral pressure, as shown by the great fatigue and striking apathy of the patient.

Four days after the abscess had been evacuated (July 30th), a marked improvement in the condition of the patient was noted by her greater vivacity and the consciousness of her condition. She answered questions more correctly, but she repeated her words. She named objects shown to her correctly. It is a remarkable fact that the patient would leave out certain words when naming pictures shown to her, while words which she could not utter before, were now spoken with facility. Bizarre word-formations no longer occurred, and the missing words were now correctly spoken, or the patient would say that she did not know them. The general symptoms disappeared, while the focal manifestations continued.

On the 2d of August, the psychic condition of the patient was by far freer, and her comprehension was rapid and correct. The careful observer would discover that she would now utter words which not long ago she did not recall, yet a certain degree of disturbance was still noticeable. To a number of questions she responded by saying: "I." Substitution of words was frequently noted. At the examination on the 9th of August, the patient was conscious of her affliction, and she took interest in its improvement. She frequently wrote down her impressions of her condition. It was remarkable, indeed, that such words as her own name, her home, and her present abode, she could not utter; still objects held in front of her and the meaning of pictures, she named almost faultlessly.

In the latter part of August, the patient could converse for a long time without any disturbances of speech being noticeable, with the exception that now and then she would miss a word. Objects and pictures held before her were invariably named correctly. Very marked improvement had taken place. It was plainly evident that the nervous elements damaged by the disease had recuperated, and the function of those parts that had been completely destroyed were substituted by others through practice. A slight disturbance, nevertheless, persisted. On the 6th of April, 1900 (eight months after the operation) the patient told me that she would occasionally miss a word while speaking. This was especially marked when she wished to name certain kitchen utensils—she was the wife of a restaurant keeper. She knew what she wanted, to be sure, but it was difficult for her to name the object correctly. However, during ordinary speech, and in reading, no disturbances whatever were noted. She would occasionally complain that while writing letters, thoughts would leave her, and that she would write double. It is a well known fact, that in cases of sensory aphasia, the disturbance recedes after a number of months, and that even years later, defects may still be found in the understanding of words. Paraphasia, paragraphia, and paralexia are more stable.

In this patient the fundus oculi was normal in both eyes, and her visual power the same as before she became ill.

In the last letter, dated April, 1911, she informed us of her complete recovery, and that not the slightest disturbances in speech existed any longer.

Multiple Abscesses of the Temporal Lobe

It is an important fact that temporal abscesses occasionally occur in multiple form. It is therefore of utmost importance to thoroughly expose the abscess cavity during the operation with dull retractors, and to carefully examine all parts involved.

OBSERVATION X, 5

Chronic Suppurative Otitis Media with Cholesteatoma Formation. Eleven Days After the Radical Operation, Two Abscesses of the Temporal Lobe were Opened. They were Separated from One Another. Death from Pneumonia.

The patient of this observation was operated on by some one on the 25th of May, 1906, for chronic suppurative otitis media, and a cholesteatoma was removed from the external auditory canal, at the same time. Nothing abnormal was observed in the beginning of the post-operative course of the case, but later on, an intracranial complication developed, and the patient was referred to me, on the 5th of June, for operation. When admitted to the hospital, he was somnolent; his temperature was 37° C. and the pulse 58 beats per minute. The wife of the patient informed us that the headaches which existed for the last four weeks on the right side, had of late become very much aggravated, and the patient was seen to constantly hold his right hand and move it back and forth over the right temporo-parietal region. The ophthalmoscopic examination showed a bilateral neuritis more marked on the right than on the left side. There was also a facial paralysis of the left side and a spastic paresis of the left arm, as well as spastic symptoms of the lower extremities that were more marked in the left leg. A diagnosis of abscess consequent to chronic middle ear suppuration (in the right temporal lobe) was made. The symptoms were explained by an inflammatory œdema of the neighboring central region, in which the facial centre was greatly participating.

The operation was undertaken at once—on the evening of June 5th. The dura was laid bare and opened in a typical manner, and about 2 cm. from the cerebral surface the aspirating cannula struck pus. An incision was now made, and at least a tablespoonful of thick pus, yellowish-green in color and very malodorous, was evacuated. The evacuated abscess cavity was now retracted and subjected to a thorough inspection, and about 1 cm. away from the first incision, pus was again seen to issue from the cerebral substance, posteriorly and below. The examining little finger discovered another cavity of similar size which was filled with the same kind of pus. Each of these abscess cavities had a depth of 4½ cm., measured from the surface of the brain. In order to widely expose the second cavity, the dura had to be split backward. The partition of brain tissue separating the two abscesses was about 1 cm. thick, and to insure better conditions for repair it was divided bluntly. The opening of both abscesses yielded at least 40 cm^3. of pus. The large cavity was drained and packed lightly with iodoform gauze. On the morning following the operation, the sensorium of the patient was freer, and at times he was mentally clear enough so that he could recognize those about him. He answered questions, and directed the preparation of his food, etc. The total hemiplegia of the left side disappeared two days after the operation, so that he was able to move his arm and lower extremity fairly well and with considerable force. On the following day, the facial paresis had also become less marked, so that the patient could point his lips to whistle. While all cerebral manifestations were rapidly receding, the patient developed, on the fifth day following the operation, a pneumonia to which he succumbed three days later. Symptoms of meningitis were at no time present.

The necropsy (*Professor Dr. Oestreich*) showed a bilateral pneumonia with flaccid myocardium, and the findings on the brain were as follows: The dura and the pia could be ablated with ease and both were free from deposits. Suppuration was found only in the field of operation. This corresponded

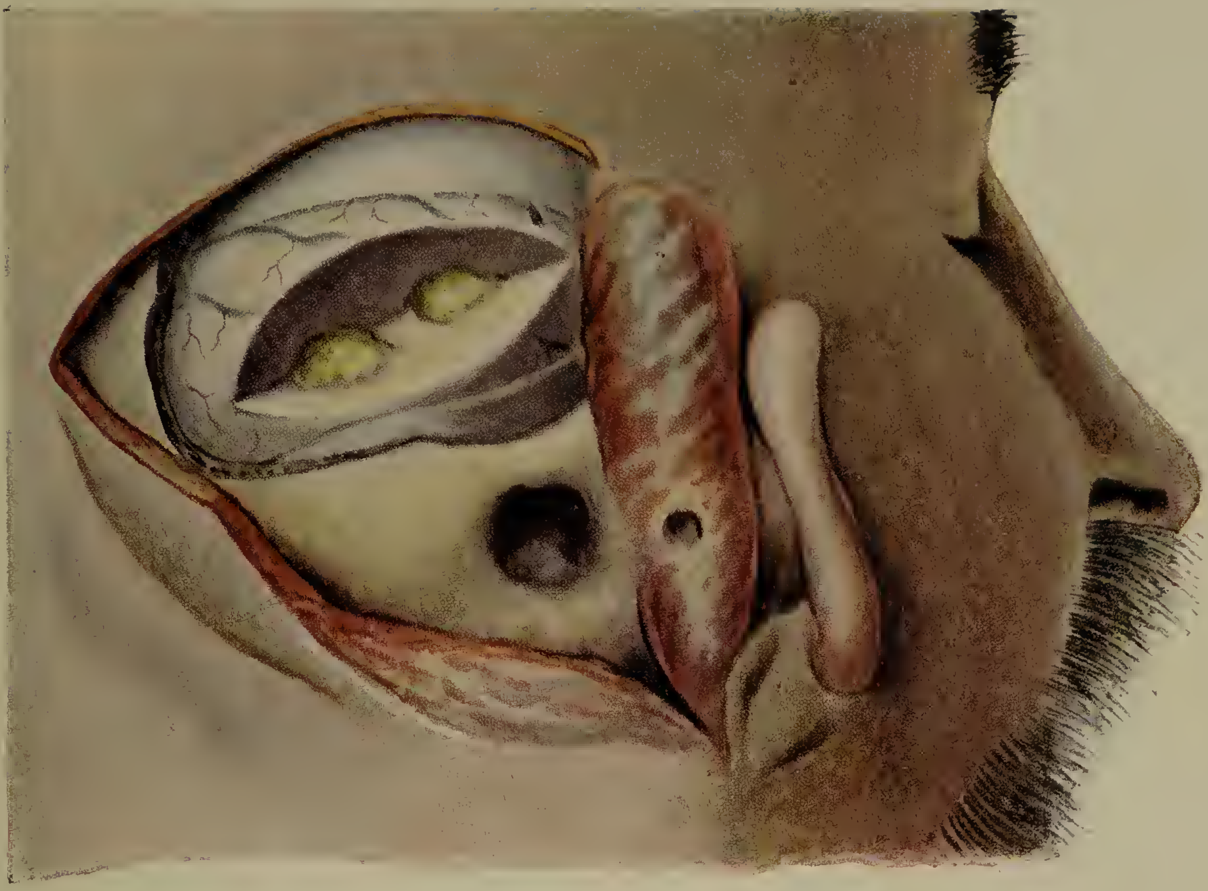


Fig. a.

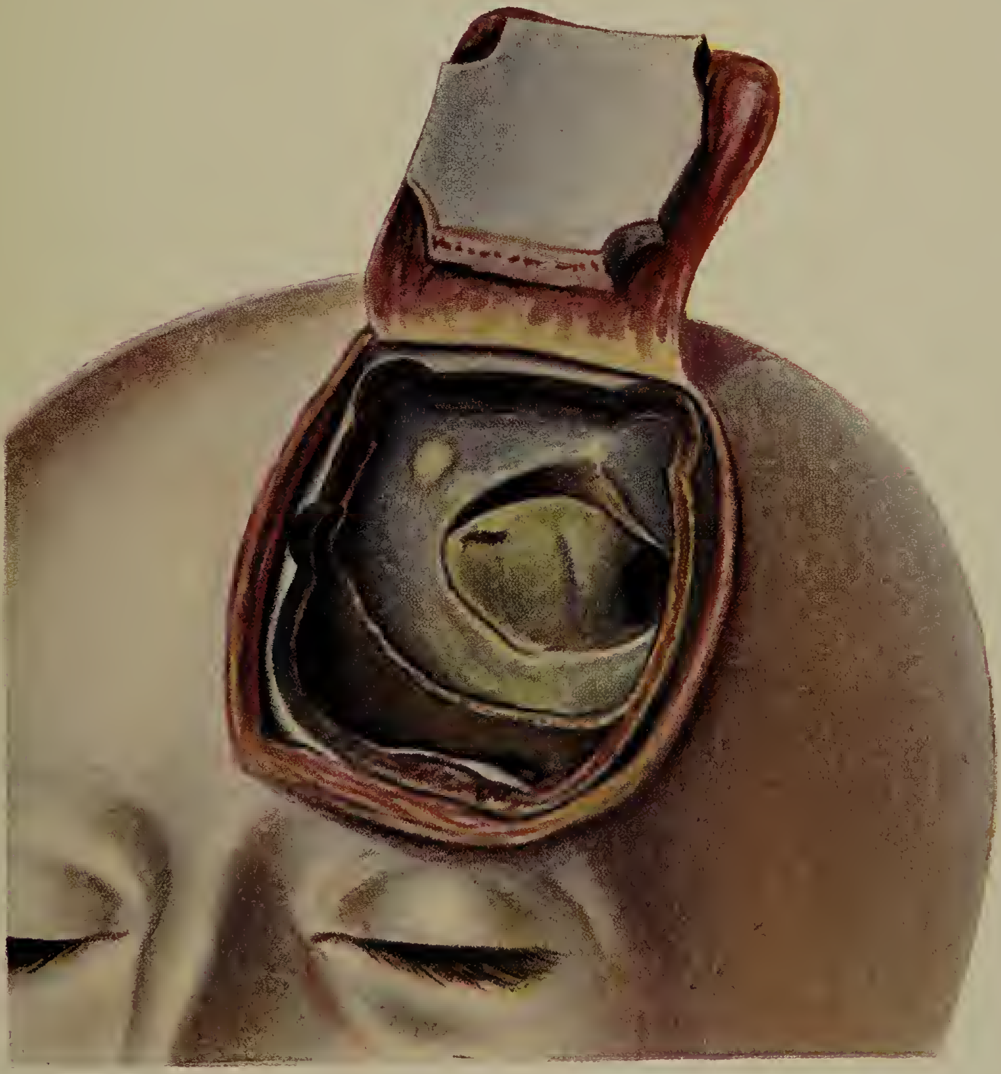


Fig. b.

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exactly to the region of the right temporal convolutions. In its immediate vicinity, the brain was greenish and showed a smeary discoloration. There was a loss of substance of moderate depth; a partition divided it in the middle. It corresponded in all characteristics to a cerebral abscess. At the base of the temporal lobe, the suppuration crept along the cerebral substance to the extent of about 4 to 5 cm. No meningitis.

Frontal section through the brain showed the abscesses completely evacuated, and no liquid pus was present. However, very narrow, green strands of pus, springing from the superficial abscess, traversed the temporal lobe. The white substance of the right hemisphere was very soft and œdematous; this caused the lumen of the ventricle to appear compressed. The abscess did not extend to the cerebellum, and the streaks of purulent deposit just alluded to did not invade the white substance of the right temporal region.

Otitic Cerebellar Abscesses

I have stated before that suppurations in the ear may cause an infection of the posterior fossa of the skull by an extension of necrotic processes from the posterior surface of the petrous portion of the temporal bone, and also from the labyrinth and from the mastoid process. I recall the case of a man, twenty-seven years of age, who was afflicted, since childhood, with a suppuration of the left ear, and in whom the focus of suppuration was found in the necrosis of a piece of bone, the size of a nickel, in the posterior part of the petrous portion of the temporal bone, in the region of the Fallopian canal; the facial nerve had been damaged. The abscess was about the size of a walnut, and it lay in the section of the cerebellum corresponding to the point of necrosis of the bone, at the angle between the tentorium cerebelli and the petrous portion of the temporal bone. Otitic cerebellar abscesses, as a rule, involve the anterior lateral section of the corresponding hemisphere. The lower wall of the tympanic cavity adjoins the fossa bulbi jugularis, and this anatomic fact demonstrates the ease with which suppurations extend into this region (compare also chapter on *Thrombophlebitis,* p. 887).

How difficult a diagnosis is rendered when extradural abscess, meningitis serosa, and cerebellar and temporal lobe abscesses affect the same patient, teaches the following observation.

OBSERVATION X, 6

Chronic Middle Ear Suppuration with Sudden Onset of Severe Cerebral Manifestations. Extradural Abscess. Meningitis Serosa. Cerebellar Abscess Opened Three and a Half Weeks Later. Death Eleven Days After from Purulent Meningitis and Cortical Abscess of the Temporal Lobe.

On the 7th of June, 1907, a student, twenty-four years of age, was admitted to the Augusta Hospital with a statement by his physician that, within the last twenty-four hours, the chronic suppuration of the middle ear with which he was afflicted, had developed threatening manifestations that indicated an endocranial accumulation of pus. The patient was of strong build, and lay in bed apathetic and somnolent, with his eyes half closed. Until the day before his admission he pursued his studies despite his ear trouble. Violent headaches, vomiting and vertigo then set in. On the evening before he was admitted, the patient could no longer sit up; and it was difficult for him to lie on the left side. When he attempted to turn in bed, he immediately vomited.

The examination of the right auditory canal showed a moderate suppuration combined with swelling and narrowing. This state of affairs did not permit a complete inspection of the eardrum. It was also impossible to make an exact examination of the hearing of the patient. The power of hearing on the right side, however, was suspended, while bone conduction was mainly limited to the right. The region of the mastoid was not swollen and insensitive to pressure or percussion. Percussion and pressure of other parts of the skull proved also negative. The right eye did not reach the extreme lateral position on looking to the side. Diplopia was not present. All movements of the eyes were accompanied by nystagmus. The examination of the fundus oculi, the trigeminus and facialis showed no deviations from the normal. The uvula deviated to the right, the soft palate was arched equally on both sides, and the tongue did not deviate one way or the other on protrusion. The patient answered questions in a nasal tone of voice and with great hesitancy. When we attempted to put him in the erect position in order to turn him to the left side, he grasped the right occipital region and complained of severe pains. This was accompanied by choking. There was no rigidity of the back of the neck, and his abdomen showed scaphoid retraction. His temperature was 37° C. His pulse was somewhat tense and fluctuated between 54 and 60 beats per minute. There were no differences in the motility, sensibility, and the stereognostic sense of both lateral halves of the body. All reflexes were considerably exaggerated, and there was ankle clonus and the *Babinski* and *Oppenheim* phenomena were present.

The threatening general manifestations indicated an immediate operation. After inserting *Heidenhain's* deligations, an osteoplastic flap was formed above the external ear, with its base directed upward. Immediately upon its completion, and after a teaspoonful of pus was evacuated over the border of the petrous portion of the temporal bone, the entire sinus mastoideus and its point of junction with the sinus transversus were freely exposed. An extradural abscess was found in this region. The bone was now chiselled away, until no more pus was seen underneath the detached dura. The sinus itself was covered with smeary granulations, and its contents could be evacuated with light pressure from the finger. The mastoid cells were laid bare, but no pus was found within them. The opening of the antrum, however, showed a somewhat purulent secretion.

Since the dura covering the temporal lobe was very tense, an aspirating needle was passed through it, and at least 10 cm^3. of a clear serous liquor was evacuated through it under considerable pressure (*meningitis serosa*). The cannula was now introduced deeply into the frontal brain, but neither fluid nor pus could be aspirated. Punctures of the cerebellum were also negative. The patient was dressed and put to bed.

Immediately after the operation, the pulse mounted to 120 beats per minute, while the temperature declined to 37° C. From the third day on and for a week following the operation the evening temperature usually fluctuated between 37° and 37.5° C., after which it continued at 37° C. The pulse became slower (two days after the operation) and in the following days it fluctuated between 70 and 90 beats per minute. The patient complained of pains in the wound, only on the day of the operation, and eight days later pains continued in the left frontal region. After the operation, the sensorium of the patient became freer, and there was a marked improvement in the vertigo. His speech became remarkably improved during the first week following the operation. However, for weeks after the operation, the patient was affected with sudden vomiting that would occur immediately upon arising in the morning, or, without any cause, at any time during the night or day. The nystagmus disappeared on the fourth day following the operation; the exaggerated reflexes became slighter, and for days at a time the *Babinski* and *Oppenheim* signs could not be elicited. The general condition of the patient markedly improved after the operation; he ate with good appetite, and was not somnolent. After fourteen days, he read books on philology, and his speech was clear throughout. It was remarkable that the patient developed a certain talkativeness that gradually increased. His speech was mainly nasal, and at times the articulation of words was indistinct or intermingled with double syllables.

An ophthalmoscopic examination, made on the 22d of June, showed, for the first time, the papillæ slightly reddened, and the veins dilated and tortuous. Both papillæ appeared somewhat prominent. The relatively good condition of the patient continued until the 1st of July. On the evening of that day it struck his attendants that he was somewhat confused. About half past nine, on the following morning (preceded by a quiet night), the patient became gradually confused; he lost his senses, and spoke incoherently. His temperature was normal, and the pulse 98. There was a striking pallidity of his face, and his respirations were somewhat accelerated. His pupils were widely dilated, and reacted to light and convergence sluggishly. An optic neuritis, with blurred papillary border and marked redness, was noticeable especially in the right eye, while in the left, the neuritis was less marked, but here the veins were very tortuous, and the papilla was distinctly prominent. Both eyes could now be moved in all directions without tremors and to the extreme lateral position. The corneal reflex was present on both sides, but on the left it was somewhat livelier than on the right. The sensibility of the face could not be tested on account of the stupefaction of the patient. The motor portion of the trigeminus was somewhat weaker on the right than on the left side. This was shown by a distinct deviation of the lower jaw to the right, when the patient opened his mouth. There were no differences in the tension of the muscles of mastication. With reference to the facialis, its right lower branch showed weaker innervation while the patient was speaking. An examination of the sense of hearing could not be made. The tongue now strongly deviated to the right on protrusion. The speech of the patient had a nasal tone, and test-words could not be uttered correctly. Almost all words of more than two syllables were senselessly interchanged. Words spoken before the patient were repeated well. He answered questions in an incoherent, confused manner, but spoke lively. When asked if he perceived vertigo, he said, "Yes"; yet he was unable to describe the sensation. His gait could not be tested. Abnormal tension or flaccidity of the joints could not be demonstrated. All tendon periosteal reflexes were lively. Patellar and ankle-clonus were present on both sides. The *Babinski* and *Oppenheim* phenomena were present. The finger-touch-nose-test was executed without ataxia.

The sudden stupefaction, the frequent vomiting and choked disc, together with the weakness in the regions of the right trigeminus and facialis in connection with the spastic-degenerative manifestations from the pyramidal tracts, pointed to a focus in the right cerebellar hemisphere. Taking into consideration the preexisting suppurative disease of the ear, an assumption of the development of an *abscess of the right cerebellum* was justifiable. In order to evacuate it, an extensive osteoplastic flap with downward base was fashioned over the right occipital eminence, after first inserting *Heidenhain's* deligations. This resection was separated from the previous cleft by a lamella of bone, barely 1 cm. in width. The old field of operation was covered with clean, healthy looking granulations, which covered the knee of the sinus transversus. The dura of the right cerebellum was moist, very tense, and barely pulsating. Palpation did not reveal fluctuation. The space between the dura and the border of the cleft of bone was thoroughly packed with vioform gauze, after which, a flap of dura was fashioned and reflected downward. At once the cerebellum bulged into the cleft. The pulsation of the hemisphere was as yet barely visible. The pia appeared moist, smooth, and the transverse grooves of the cerebellum were somewhat vascular. Palpation of the hemisphere itself disclosed distinct fluctuation. To protect the subdural pia-arachnoid meshes from infection, they were tamponed with vioform gauze all the way around. A needle was inserted over the pole of the protruding cerebellum, upon the introduction of which, thick, yellow pus issued in drops. The hemisphere was now split with a double-edged knife along the hollow needle, and about a wineglassful of pus was evacuated from a depth of about 3½ cm. A drain was introduced into the abscess cavity, and the entire space loosely packed with vioform gauze. After the rest of the cerebellar surface had also been covered with gauze, the osteoplastic flap was replaced, and a voluminous dressing applied.

Five days after the evacuation of the pus, the patient had remarkably improved. The stupefaction and indistinct speech disappeared. The reflexes were still exaggerated, and the weakness in the trigeminus and facialis persisted, but the ankle and patellar clonus had disappeared. High temperature and an acceleration of the pulse set in for the first time, on the 7th of July. The stupefaction became marked again, and the patient was failing rapidly. Rigidity of the back of the neck could at no time be demonstrated. At the first change of dressings (two days after the operation) no more pus was found, and the drain was therefore shortened, and the vioform gauze renewed. The entire half of the cerebellum was in a condition of red softening.

At a later change of dressings, on July 8th (six days after the operation), the cerebellum, together with the drainage-tube, were prolapsed far above the level of the skull, and the entire softened mass could be removed with a gauze sponge. On the same day, the *Oppenheim* and *Babinski* phenomena reappeared, the tongue distinctly deviated to the right again, and nystagmus and visual paralysis to the right could be demonstrated. There was a decided bilateral optic neuritis.

Since all these manifestations as well as the stupefaction increased in intensity, the malodorous softened masses of the cerebellum were removed with the finger on the 11th of July (nine days after the opening of the abscess), and the entire defect was packed with moist, iodoform gauze. Punctures of the temporal and occipital lobes were negative. The patient died on the 13th of July under increasing somnolence.

The post-mortem examination made by *Professor Oestreich* showed a suppurative meningitis and a cortical abscess in the temporal lobe. The arachnoid of the convexity of the brain appeared grayish-white in many places, and it also showed many jellylike, yellowish infiltrations (beginning suppurative infiltrations). At the base of the brain, especially in the region of the pons, extensive suppurative infiltrations were found in the arachnoid. The right cerebellar hemisphere was softened, the opening made into it during the operation was present, but no other abscesses.

Between the dura mater and the arachnoid on the right side in the middle fossa of the skull a very slight hemorrhage was present. An oblong, small cortical abscess was found in the adjacent white substance of the right temporal lobe. The sinuses were free from thrombi. The internal organs showed no abnormalities except that the spleen was somewhat hyperæmic, soft, and hypoplastic.

Extradural Otitic Abscesses

Infection from the middle ear may also lead to extradural accumulations of pus without involving the brain itself. The symptoms in these instances are similar to those of cerebral abscess, so that a differential diagnosis is generally well nigh impossible. In trephining, we should, therefore, make it a practice to at first detach the dura of the middle or the posterior fossa of the skull, as the case may be, from the petrous portion of the temporal bone, for some distance, in order to expose (extradurally) the vicinity of the tegmen tympani and the upper semicircular canal or that of the porus acusticus internus. Since it is a fact that the fossa sigmoidea is subject to easy infection, the writer makes it a practice to lift the sinus sigmoideus from the sulcus mastoideus for the purpose of examining the posterior surface of the petrous portion of the temporal bone. For the above procedure and the examination of the superior and posterior surfaces of the petrous portion of the temporal bone, it is important that a rim of bone corresponding to the superior border of the petrous portion of the temporal bone be preserved; it acts as a sort of rafter and prevents the caving in of the breaches made by the trephine.

OBSERVATION X, 7

Otitis Media Following Measles. Chiselling Open of the Mastoid Process of the Temporal Bone. Radical Operation. Meningitis Serosa in the Region of the Temporal Lobe. Extradural Abscess on the Posterior Surface of the Petrous Portion of the Temporal Bone Extending to a Depth of 78 mm. Cure.

A boy, nine years of age, became afflicted with double middle-ear inflammation during an attack of measles. The left ear healed completely after a paracentesis of the eardrum, while on the right side, *Dr. Jansen* had to chisel open the mastoid on the 2d of May, 1902. After this operation the patient became afebrile. The wound was in good granulating condition and the temperature normal, when, on the 20th of May, it suddenly mounted to 38.3° C. and continued at this height in the following days. The boy complained of frontal headaches that were limited to the right side. Percussion and pressure showed no sensitiveness on any part of the skull. The surroundings of the right eye were somewhat swollen. This was accompanied by a slight degree of rigidity of the neck which became more marked on the 22d of May, and on the same afternoon the patient also complained of occasional double vision.

On the afternoon of the 23d, a right-sided abducens paresis set in, while the ophthalmoscopic examination was negative. The frontal headaches, that were exclusively limited to the right side, became so violent on that afternoon that the boy constantly moaned, and his sensorium became cloudy; however, pain on pressure of the skull did not exist. Until then the appetite of the patient was tolerably good. He was etherized on the 25th, and *Dr. Jansen* examined the granulating cavity and scraped out the spongy granulations which were filling it. A slight retention of pus was discovered corresponding to the point of the mastoid, and also in the tegmen tympani which was very thick and hard, and the vessels were remarkably turgid. The dura mater was hyperæmic. It did not pulsate, but was otherwise free. Puncture of the sigmoideus evacuated blood, and the puncture of the temporal lobe yielded clear cerebro-spinal liquor. There existed, therefore, a serous infiltration of the brain and the membrane covering it.

On the morning of the 26th, the condition of the patient was perhaps somewhat better; the rigidity of the neck was somewhat slighter; the temperature, on the other hand, rose in the evening to 36.7° C., and the frontal headaches of the right side and the paralysis of the abducens persisted, associated with photophobia. During the change of dressings on the 27th, a large quantity of pus was evacuated from the region of the tube, and *Dr. Jansen* completed the radical operation on the 28th of May. He removed the malleus and the incus, curetted the opening of the tube with a sharp spoon, and packed the cavity with iodoform gauze. After this procedure, the temperature fell, and on the evening of the day of that operation, it was 37.8°, and on the following morning 37.5° C.; pulse 112 and 100. On the next morning, the condition of the patient was much improved.

On the evening of the 29th, however, he became worse again and at nine o'clock, his temperature rose to 39.2° C. and the pulse to 140. The boy was very restless and uttered loud cries whenever he was spoken to or touched. The paralysis of the abducens continued unchanged, and the eye could be moved only to the median line. On the same evening, a slight paresis of the rectus internus muscle could be demonstrated. The ophthalmoscopic examination showed no changes. Percussion of the skull showed it to be painful on the left side and in the anterior parietal region, but in no other place. The excruciating, right-sided frontal headache continued, yet neither pressure nor percussion of the forehead caused pain. There was a marked photophobia and rigidity of the neck. The pulse was of good tension, and the abdomen not retracted. The taking of liquids was satisfactory, and the bowels of the patient moved daily. On the morning of the 30th of May, his condition was about the same—temperature 39.6° C., pulse 140.

Since the course of the disease caused me to suspect the existence of suppuration in the depths, I proceeded, assisted by *Dr. Jansen,* on the 30th of May, to open the cavity of the skull. The middle fossa was exposed by means of *v. Bergmann's* flap-formation. The dura was very tense and showed no pulsations. It was thoroughly washed off with bichlorid of mercury, and a medium sized cannula was introduced into the temporal lobe to a depth of 3 cm. Aspiration evacuated a slight quantity of liquor, the microscopic examination of which showed it to be free from round cells. While the cannula was being withdrawn, a stream of clear liquor of considerable quantity projected from the puncture made in the dura (*meningitis serosa*).

The dura was now bluntly detached from the tegmen tympani and the superior surface of the petrous portion of the temporal bone. The same modus was practised as in extirpation of the *Gasserian* ganglion. The ablation of the dura was extremely difficult. It was very thin, and special care had to be exercised. The brain, together with the intact dura, was now slightly lifted with a spatula, but no pus could be seen as yet.

I now carefully worked my way to the eminence of the upper semicircular canal and to the hiatus canalis Fallopiæ and was able to follow the nervus petrosus superficialis, entering into the ganglion geniculi for a distance of about 1 cm. medianward. Only after the dura was lifted from the superior border of the petrous portion of the temporal bone in the depth, during which the sinus petrosus superior was torn and gave rise to a considerable transient hemorrhage, and after I had reached the posterior surface, a small quantity of pus was seen issuing from this region. The dura was now detached from the posterior surface of the petrous portion of the temporal bone, to a considerable extent, and this led into an extradural abscess cavity which contained quite a large quantity of pus of a creamy consistency. The cavity extended to the front for a considerable distance, below and medianward toward the bulbus venæ jugularis, and for a still greater distance, to the meatus auditorius internus.

We were entirely unsuccessful in exposing the fossa jugularis, the acusticus or the facialis.

Upon lifting off the dura, a small granulating spot was seen in the depth on the posterior superior border of the petrous portion of the temporal bone from which pus was oozing. Below this spot, a small necrotic area of bone was found on the posterior surface of the petrous portion which was evidently the cause of the abscess. A narrow fistula connected it with the antrum. The overhanging border of bone was now removed with a narrow chisel, and this opened a cavity at the border of the petrous portion of the temporal bone from which a large quantity of pus was evacuated. The sound extended very deeply in the posterior wall of the petrous portion. Further chiselling away of the overhanging border of bone rendered the abscess cavity in the posterior fossa of the skull accessible. It was shown to extend downward and medianward toward the internal auditory canal and the bulbus jugularis for a considerable distance. The median line of the abscess cavity corresponded to about the place where the abducens continues forward over the superior border of the petrous portion of the temporal bone.

Since no more pus was found in the depth, the length of the cavity was measured with the sound. It was 7.8 cm. from the surface along the superior border of the petrous portion of the temporal bone. In order to reach the limit of the abscess cavity, I had to progress medianward, to a distance of 2.6 cm. from the projection of the superior semicircular canal. A medium sized drain was now introduced and the large abscess cavity packed loosely with iodoform gauze. The operation lasted about two hours, and the patient was returned to bed, with a fairly strong pulse of about 120 beats per minute and without symptoms of collapse.

The further course of the disease was excellent. While on the 31st of May, the temperature was 39.6° C. and the pulse ranged in the neighborhood of 140 beats per minute, from the 1st to the 4th of June they were 38.5° C. and about 108, respectively. From the 5th of June, the temperature ranged between 36.8° and 37.5° C., and the pulse fluctuated between 84 and 92 beats per minute. At each dressing (every other day), the deepest parts of the wound were exposed to view with the spatula. However, while dressing him, the patient had to be placed under superficial ether narcosis on account of great pain occasioned by the tamponade. This was continued for three weeks. On the 31st of May, no more pus was present, and the dura pulsated in a normal manner.

The abducens paralysis was less marked as early as on the evening of the operation. The eye could be slightly moved over the median line. The photophobia had somewhat decreased, the general condition of the patient was better. The frontal headache completely disappeared. The boy complained of no pains whatever, except that on questioning him, he stated that the right ear hurt. On the 31st of May he perceived slight rigidity of the back of the neck. His general condition, however, was very good. He assumed a bent position toward the right side and he kept his head in this attitude despite the fact that it caused his head to be turned to the window, and the photophobia, while not so marked as before the operation, was, nevertheless, demonstrable. He was annoyed by the forced position. The attitude to the right persisted for a few days.

On the 1st of June the boy was still weak, but he answered all questions quickly and without hesitation. All he complained of was rigidity of the back of the neck when he moved his head. The photophobia had almost completely disappeared and the paralysis of the abducens was by far less pronounced than heretofore. Outward movement of the eye caused the lateral border of the cornea to reach a point about 2 to 3 mm. distant from the canthus externus. The patient slept quietly and on the 2d of June the rigidity of the back of the neck had almost completely disappeared.

On the 4th of June, a slight paresis of the lower branch of the facialis set in which gradually increased until the 9th of June, at which time it had also involved the upper branch. It then gradually disappeared together with the paresis of the abducens. The boy left the bed about the end of June. He gained about three pounds in weight, and by the 14th of July he had gained eleven more pounds. At that time, the wound in the skull had completely cicatrized.

The patient remains cured for the last nine years and does not complain of the slightest subjective symptoms. The scar in the skull is narrow, and with the exception of a small anterior section of it, it is within the hair line; posteriorly, it is covered by the external ear which is closely applied to the side of the head. In the region of the defect of the bone which is as wide as a thumb, the skin is at no higher level than the rest of the skull, and it is not retracted. Cerebral pulsations are distinctly visible and palpable. The patient is able to hear words spoken in a whisper for a distance of over 1 metre.

In this case, many symptoms are of importance. Suppuration in the region of the posterior surface of the petrous portion of the temporal bone may cause a rigidity of the back of the neck. This disappeared three days after the pus had been evacuated.

The paralysis of the abducens is easily explained by the close relationship of the nerve to the phlegmonous abscess. I had to advance 26 mm. medianward from the projection of the superior semicircular canal to the upper border of the petrous portion of the temporal bone, in order to reach the limit of the suppuration. At this depth, we find the abducens coursing to the front, over the point of the pyramid of the petrous portion to the middle fossa of the skull. In this instance, the inflammatory œdema which is always present in the region of septic suppurations has sympathetically affected the nerve. Soon after the evacuation of the pus, however, the paralysis rapidly diminished (it was less marked as early as on the evening of the operation), but it took a number of weeks before function was completely restored.

It is noteworthy that in this case a symptom developed after the operation which is frequently observed in morbid processes of the posterior fossa of the skull, i.e., the turning of the head and the body to one side (in this case, to the affected side). This manifestation was more striking for the reason that the boy was compelled, by reason of this forced attitude, to look directly into the light of the window, although there existed a continuous photophobia after the operation. This symptom disappeared after a few days.

The spontaneous frontal headaches which were limited and persisted on the right side seemed to be of diagnostic importance. Pressure and percussion over the entire skull was not perceived by the patient as painful, with the exception that, on the evening preceding the operation, he complained of pain when his left anterior parietal region was being percussed, while the abscess was located on the right side in the posterior fossa of the skull near the median line. The statements of the boy were very reliable, because he did not exaggerate; on the contrary, he tended to belittle his sufferings. The bilateral frontal headache may be explained by the following anatomic conditions.

The tentorium cerebelli is inserted into the upper border of the petrous portion of the temporal bone and encloses here the sinus petrosus superior. It is innervated by the ramus recurrens *Arnoldi* of the first branch of the trigeminus. According to *Arnold,* this recurrent branch also supplies with a few very fine fibres the wall of the sinus petrosus superior. The dura mater is innervated in the region of the anterior fossa of the skull and in the frontal territory by the ramus meningeus anterior of the nervus ethmoidalis that also springs from the first branch of the trigeminus. The suppuration in this case was very close to the point of insertion of the tentorium cerebelli to the superior border of the petrous portion of the temporal bone, and the nerve fibres coursing here were irritated by the suppurative process which also explains the transfer of the irritation to other branches of the same nerve (trigeminus I). This explanation is supported by the fact that as early as on the evening of the operation, the unilateral headache had disappeared to recur no more.

The assumption that, similar to the abducens, the trunk of the trigeminus, which is in close relation to it (laterally) and runs over the superior border of the petrous portion of the temporal bone in its course to the cavum *Meckelii,* would also become sympathetically affected, is here justified. However, if the trunk of the trigeminus were irritated, the pains would not be located and persist in the one particular region exclusively (frontal area). They would be perceived by the patient in a number of places or perhaps in the entire distribution of the trigeminus, and would not be confined to one particular anatomic focus as was the case in this patient.

Meningitis Serosa ex Otitide

Besides cerebral, cerebellar, and extradural processes of suppuration occurring in otitis media, acute circumscribed collections of liquor cerebro-spinalis may also result in connection with suppurations of the middle ear and in the neighboring osseous structures. These may be under high pressure and may restrict the space within the closed skull, like a neoplasm or an abscess.

I am of the opinion that this process is nothing more than an inflammatory œdema that may be secondary to a pus focus. It may give rise to all clinical manifestations of a septic meningitis or cerebral abscess. The operation will, as a rule, uncover a suppurative process in the cavum tympani, in the antrum or the mastoid cells, or perhaps a perisinuous extradural abscess. The exposure of the temporal lobe or the cerebellar hemisphere by the trephine will show marked tension of the dura and no or, perhaps, barely visible pulsations. Cerebral puncture will discover no pus, but a clear liquor that will issue under strong pressure from the openings made with the cannula. Since operative removal of all affected tissues may bring about the disappearance of all cerebral manifestations or even a cure, as I have seen it to be the case in a number of instances, we are furnished with proof that, as a matter of fact, we were not dealing with a cerebral abscess. At other times again, the punctures may not be sufficient and in that event the dura will have to be opened, which is best accomplished by the formation of flaps.

The clinical picture is in these cases analogous to a condition of *meningitis serosa spinalis* of which I shall speak when dealing with the surgery of the spinal cord. Besides the chronic form there also exists, in these cases, an acute variety which is brought about by suppurative or necrotic processes of the bone of the arches or bodies of the vertebræ.

The following observation offers an example of meningitis serosa of the posterior fossa of the skull. It also teaches that a suppurative process of the temporal lobe may occur in combination with the former.

OBSERVATION X, 8

Otitis Media. Paracentesis of the Ear-Drum. Chiselling Open of the Mastoid. Abscess of the Temporal Lobe Opened Three Months Later. Apparent Cure, Outside of Slight Manifestations. Six Months Later, Symptoms of a Fluctuating Character Pointing to the Right Cerebellum. Meningitis Serosa. Cure.

The patient was a girl nineteen years of age. Family history, negative. Two years prior to her admission to the hospital, she was operated on for perityphlitis. From that time on there existed obstinate constipation. On the 25th of September, 1909, she became ill with violent pains in the right ear. Three days later her physician incised a swelling in the region of the mastoid process of the temporal bone. No pus was evacuated at that time, and symptoms of suppuration of the middle ear were absent. When the patient was admitted to the Augusta Hospital (2d of October, 1909), she complained of violent pains in the entire right occiput and of vertigo. The right ear-drum was prominent, injected and pulsating. The soft tissues of the neck were doughy in consistency and swollen from the right mastoid to about the middle of the sterno-cleido-mastoideus. A healthy looking incised wound, about 3 cm. long, was found at the upper point of insertion of that muscle. There were no signs of thrombosis of a sinus or of the jugular vein. The right mastoid was extremely sensitive to touch and percussion.

A diagnosis of acute otitis media and mastoiditis was made. Paracentesis of the drum was performed on the 2d of October, and a few drops of pus were evacuated. The right mastoid was also chiselled open, and its cells as well as the antrum were found filled with pus. The sinus mastoideus was visible for a short distance in the upper portion of the wound. It was not thrombosed. The dura showed a grayish-green discoloration. The cavities of the bone were thoroughly cleansed, and the wound packed. The symptoms abated, and the temperature fell.

The wound healed gradually, and the pains in the ear disappeared. Slight rises of temperature persisted; occasionally as high as 38° C. (evening). From time to time, the patient was somewhat stupefied, and she complained of dizziness. This was occasionally accompanied by vomiting, which was attributed to a chronic disorder of the stomach, from which she was suffering. She had been afflicted with total achylia gastrica accompanied by obstinate constipation for a long time. Symptoms of meningitis were absent. Repeated examinations of the fundus oculi showed no changes whatever. The movements of the eyes were free, without nystagmus. When the patient was looking downward, she had a sensation as if everything were whirling around her from left to right. In the following weeks, these manifestations, especially the vertigo, regressed, so that in the beginning of November, the patient was able to leave the bed, and on the 23d of December, 1909, she left the hospital.

On the 27th of January, 1910, the patient was readmitted to the hospital in a critical condition. She complained of very violent pains in the whole head. She became dizzy and vomited at the slightest movement of the head. The region over the right ear was highly sensitive to touch and percussion. The fundus oculi was now also normal, and the pupils reacted promptly. There existed, however, a coarse nystagmus that was especially marked when the patient was looking to the right. There was also a weakness in the left arm and in the left lower extremity and a considerable exaggeration of the left knee-phenomenon.

These findings, coupled with the anamnesis, caused us to suspect the existence of a temporal abscess. On the 28th of January, 1910, the patient was trephined in the left temporal region, in the usual manner. The dura was found tense and it did not pulsate. A flap of dura was formed, and the pia-arachnoid showed a milky cloudiness, and was œdematous. After protective tamponade, puncture between the base of the central region and the temporal lobe at a depth of 3½ cm., yielded 12 cm^3. of an inspissated, cloudy, sanguinolent fluid. The cortex cerebri was now incised in this place, and a medium sized rubber drain, from which a few drops of puriform liquor trickled away, was inserted. Since the abscess was comparatively small, and remembering the occasional occurrence of multiple foci of suppuration (see Observation X, 5, p. 861), I punctured the lobus temporalis in various directions. The punctures were negative. The wound was now packed, and the osteoplastic flap replaced. A few days later, drainage from the tube ceased, and the tube was removed. A cerebral prolapsus, the size of an apple, was now present, and the vertigo and inclination to vomit had almost completely disappeared. Two weeks later the nystagmus was also gone. Soon thereafter, the patient was able to sit up in bed, and after a little while, she could get up and walk about, and in the beginning of May, the cerebral prolapsus had regressed so far that the trephine opening could be completely closed. The granulations were removed together with a strip of necrotic bone which was found at the border of the flap, after which the latter was sutured into the cleft (4th of May, 1910). On the 19th of May the patient was discharged cured.

About the end of June, 1910, she came back to the hospital. At this time, she complained of hissing and knocking noises in the head, especially in the region of the right ear, and of occasional nausea and vertigo. *H. Oppenheim* examined the patient and found besides adiadochokinesis of both hands and exaggerated tendon phenomena of both arms and lower extremities, nothing pathologic. There were neither nystagmus nor ataxia, and the fundus oculi was also normal. The patient remained in bed for eight days, after which all subjective manifestations disappeared. She then left the hospital, but returned fourteen days later with similar manifestations. Despite the few objective symptoms that resembled those mentioned above, we were forced to assume (consultation with *Professor Oppenheim*) the existence of a morbid process in the right posterior fossa of the skull (abscess, meningitis serosa). On the 20th of July, 1910, a hole was drilled in the region of the right cerebellar hemisphere, and punctures were carried out in all directions, but without result. We therefore concluded to abstain from any further operative manipulations, and at the end of July the patient was sent to a sanitarium. The physicians of that institution attributed all morbid manifestations to hysteria. It must be mentioned, however, that of late, the patient showed great irritability of temper, and she was somewhat exalted. On the 26th of August, she left the sanitarium and returned to the home of her parents.

In the course of the following weeks, during which time the patient frequently visited the hospital and was examined by *H. Oppenheim*, there developed symptoms which spoke more and more for a morbid process in the region of the right cerebellar hemisphere. These were mainly: excruciating headaches in the right occiput; nystagmus when she was looking to either side; and cerebellar ataxia. On the 9th of September, 1910, the patient was admitted to the hospital, and on the 14th of September the right and a small median border of the left cerebellar hemispheres were exposed in the usual manner. Upon opening the tense dura of the right side, a stream of clear liquor was ejected. After the flap was fashioned, the pia-arachnoid was found strongly œdematous; this was especially marked in the region of the vermis. The œdema was removed by punctures and incisions into the meshes of the arachnoid. After the aspirating needle was withdrawn, a cyst, about the size of a hazelnut, formed again in the region of the vermis, so that considerable arachnoid structure had to be taken away. A large quantity of liquor was evacuated also from below (vertebral canal). A careful inspection of the region of the right cerebellum, during which the facialis and acusticus were rendered distinctly visible, showed nothing of a pathologic nature. Palpation and numerous punctures of the cerebellum were also negative. The findings were those of a meningitis serosa. The osteoplastic flap was replaced, and after repositing the dura, it was sutured into position. No drainage.

A few days after the operation, the headaches, nystagmus, vertigo and ataxia had completely disappeared. The general condition of the patient also remarkably improved, so that, on the 22d of October she was discharged cured.

The cure of the patient was permanent, and she was able to work as before.

On the 25th of April, 1911, a folding-door fell on her head exactly over the right cerebellar hemisphere. This was followed by a recurrence of the previous disturbances: headaches, marked vertigo, and occasional vomiting. She was admitted again to the hospital on the 30th of May. No external injury was found. The trephined area over the right cerebellum was somewhat bulging. The fundus oculi was normal. The eyes did not reach the extreme lateral position. When the patient was looking to the side, there occurred strong vertigo and nausea; this was occasionally accompanied by coarse nystagmus. Ataxia, motor weakness and pathologic reflexes were absent. After the patient had remained in bed for a few days, she began to improve. The bulging of the flap receded. On the 15th of June she walked out of the hospital, and did not complain of any disturbance. On the 20th of August, 1911, she paid us a visit, and was found in blooming health.

Cyst Formation in the Brain in Connection with Otitis Media

Certain processes may develop in connection with inflammations of the middle ear which at first appear in the form of serous meningitis and then give rise to a collection of fluid in the substance of the brain akin to cyst formation and lead to severe clinical manifestations. The following example serves as a good illustration.

OBSERVATION X, 9

Acute Inflammation of the Middle Ear with Symptoms of Meningeal Irritation. Later on, Symptoms Indicating Temporal Abscess. Cyst in the Central Region. Opening and Drainage of the Cyst, Followed by Severe Manifestations and Jacksonian Spasms. Gradual Improvement. Cure.

A girl, five years of age, had always enjoyed good health until about eight weeks prior to her admission to the hospital. She was always lively, active, and physically well developed. At that time, a severe inflammation of the right middle ear set in, which was treated medically. Severe headaches developed in connection therewith, accompanied by vomiting. These attacks occurred, in the beginning, once every other day, but later they became more frequent, and on one occasion an attack lasted continually for eight hours. The health of the girl was rapidly failing. She was completely conscious, however, and no attacks of vertigo were observed. Between the attacks, her general condition was comparatively good.

She was admitted to the hospital on the 17th of July, 1905. While she complained of no manifestations at that time, she was very emaciated. Her speech was vivacious without disturbances, and the intelligence of the patient corresponded to her age. Repeated examinations showed the following conditions: Slight swaying to both sides noted occasionally when the patient was walking. The phenomenon of *Romberg* could not be tested. Both plantar reflexes were lively, and the patellar reflex was more active on the right side than on the left. The ophthalmoscopic examination showed the right papilla blurred, its veins dilated, and there was beginning choked disc. The contours of the left papilla were also indistinct. The skull was sensitive to percussion in its entire extent, more so on the right than on the left side. This sensitiveness, however, could not always be demonstrated. The right ear-drum was somewhat retracted but not perforated. The auditory canal was free from pus. The patient could hear words spoken in a whisper at a distance of 1 metre on the right as well as on the left side. The pulse was moderately tense and regular; its frequency 100, temperature 37.0° C.

On the day of her admission to the hospital the patient was very lively until noon; she ate, drank, and played with the other children. About two o'clock in the afternoon, she became quieter, began to moan, complained of headaches, and burrowed the right side of her head into the pillow. When moving she uttered loud cries, sought to steady her head with both hands, and returned to her right position again. The head was, at that time, extremely sensitive, especially on the right side, above and behind the ear. Both lower extremities were flexed and the patellar reflexes exaggerated. After a little while, she ejected her food soon after its ingestion. During this attack, the pulse was 110, and of moderate tension.

In the following five days, these attacks were repeated with short intermissions. The headaches became more severe, and they kept the child awake. She left her right lateral position only rarely and never assumed the dorsal decubitus of her own accord. The sensitiveness of the right half of the head to percussion became gradually more marked and finally localized itself about the breadth of three fingers above the right external ear. During these days, the temperature fluctuated between 36° and 39° C. The child had at that time lost considerably in weight and she became weaker right along so that operative intervention could not be postponed any longer. We suspected an abscess in the right temporal lobe consequent to otitis media.

On the 25th of July, the mastoid cells were laid open. No trace of granulation nor pus was found within them. The incision was, therefore, enlarged upward, and a piece of bone the size of a half dollar was taken away above the mastoid process. The presenting dura was very tense and did not pulsate. Three punctures were carried out toward the parietal and occipital lobe without results. The fourth puncture, however (directed inward, upward and forward), yielded about 10 cm^3. of a reddish fluid which coagulated in a short time after its aspiration. While the cannula remained *in situ,* the brain substance was split to an extent sufficient to permit the introduction of a thin drain. During this step of the operation, a few more cubic centimetres of the above fluid were evacuated. The wound was packed with vioform gauze.

After awakening from the anæsthesia, the patient vomited only little, and no paralyses could be demonstrated on her arms or lower extremities. The left angle of the mouth, however, was somewhat drooping, and the left half of her face appeared somewhat weaker than the right. In the following days, clonic, quickly vanishing twitchings were observed from time to time in the affected half of the face. The child lay mainly on the left side, it spoke little, and was evidently very exhausted. In the following three days, she vomited no more. All reflexes were normal. In the following days the quality of her pulse improved, and its frequency ranged between 110 and 130 beats per minute, while the temperature fell from 38.9° to 36.5° C. On the fourth day (about noon), spasms suddenly set in. They began with short twitchings in the left extremities and, a few seconds later, they involved the face and also the right half of the body. The child was at that time in a forced position on the left side, with distorted upper and extended lower extremities, while her abdomen was rigid and retracted. She was unconscious, and foam issued from her mouth. The temperature now rose to 38.8° C., and the pulse quickly mounted to 200 or more beats per minute.

These seizures were very frequent. They were of a *Jacksonian* type and mainly affected the left half of the body. They almost always began in the left lower extremity. The attacks were ushered in with an outcry and were soon followed by clonic-tonic twitchings of the left extremities and the left half of the face, with distinct participation of the muscles of mastication. During all this, the patient was groaning. The pupils were moderately dilated, rigid and did not react to light. The corneal and conjunctiva reflexes were absent on both sides. The tendon and periosteal reflexes of the right side were moderate, and those of the left increased to a degree of slight clonus. Now and then, spasms of the muscles of respiration were observed. The pulse was fluttering. About one o'clock in the morning, the attacks gradually became less frequent, and finally ceased.

In the following days the temperature was 36.5° and 37° C., and the child was quickly failing. It did not react; it had involuntary passages, and when fed, it swallowed poorly. In the following four weeks no more spasms occurred, the pupils reacted, but neither tendon nor periosteal reflexes could be elicited. The little patient lay in the right lateral decubitus, totally apathetic with rigidly opened eyes. The wound offered a healthy appearance, and a moderate quantity of liquor issued from it. A cerebral prolapsus, the size of a small apple, developed simultaneously. The child became emaciated to a skeleton.

About the end of the fourth week after the operation, the general condition of the patient improved somewhat. The cerebral prolapsus had receded to the size of a walnut; hardly any liquor issued from it. After a few days, the girl began to look around, and she attempted to raise her head. While so doing she uttered inarticulate sounds and laughed and cried quietly. At that time her intelligence was practically nil; no matter what was handed to her, she invariably carried it to her mouth and bit on it. Her appetite became voracious, and she gained rapidly in weight. After four weeks the child was very much stronger, she was able to walk about unsupported, but she used her weaker arm (the right) less than the left. This was accompanied by a marked motor unrest. Her speech had not as yet returned, she was not able to repeat words spoken in a whisper, but her understanding was somewhat better. The state of her nervous system was apparently normal, and the choked disc had almost completely disappeared. The size of the prolapsus cerebri was now that of a hazelnut, and the wound was about the size of a silver quarter of a dollar; it was granulating satisfactorily.

In one more month the improvement in the general condition of the patient was remarkable. She looked the picture of health, exercising in bed and climbing about; her movements, however, were somewhat apish. Her walk was normal; in complicated movements she preferred to use the left hand the power of which was greater than that of the right. Both halves of the face were equal, and no differences were noted on moving both sides. The general impression created by the patient was that of an idiotic child; she only laughed and uttered peculiar sounds when spoken to. When engaged for a long time, she would move her lips as if trying to repeat words, but not a single articulate word was uttered by her. She understood when exhorted and evinced satisfaction when some one approached her. Her bowel and bladder functions were still involuntary.

The condition of the patient four months after the operation was as follows:

The cerebral prolapsus had gone. A moderately retracted scar was present behind the right ear. The entire head was insensitive to percussion, and she had not vomited for months. The choked disc had disappeared and the pupils reacted promptly to light and convergence. The reflexes showed no peculiarities, and the right patellar reflex was somewhat exaggerated.

She was always in good humor, and her intelligence improved somewhat of late. She was able to speak words spoken before her, yet it was doubtful whether she understood what she was saying. An active motor unrest was still present so that the patient could not keep still in bed. The pulse and temperature ranged within normal limits, and the general condition of the girl was excellent.

A letter from her mother dated February 2, 1907, informed us that the child was normal physically in every respect. No disturbances whatever were observed after the discharge of the patient, and she had made good progress in her development. The mental condition of the girl, now seven years old, remained somewhat behind, although spasms occurred no more. She frequented the kindergarten. Her speech completely returned and the last report, dated June, 1909, described her as entirely normal mentally for her age.

Thrombophlebitis

We have seen above, that suppurations of the middle ear lead to thrombosis of the neighboring sinuses by direct extension. The sinus sigmoideus is most frequently affected, and this is only natural when we consider its anatomic relationship. As is known, the lower wall of the tympanic cavity adjoins to a great extent the fossa bulbi jugularis. The bony partition may be represented by a lamella about the thickness of a sheet of paper, or it may even be interrupted, so that the mucous membrane of the tympanum is in direct contiguity with the sinus.

The following history may serve as an example of a case of

Septic Thrombosis of the Sinus Sigmoideus and the Vena Jugularis

OBSERVATION X, 10

Chronic Suppurative Otitis Media. Septic Thrombosis of the Vena Jugularis. Death from Multiple Pulmonary Abscesses.

A girl, fifteen years of age, who was suffering for a long time from suppuration of the middle ear, was seized with a severe chill about ten days before she entered the hospital. She then became very ill, and her physician stated that the clinical picture continued uniform and was characterized by high fever associated with chills which occurred daily and by the absence of special local symptoms. While the anamnesis pointed to an infection of the right ear, from which focus the general systemic invasion originated, objective examination of the patient disclosed only considerable sensitiveness to pressure of the right side of the neck. The head was kept in a wry-neck position, and there was no œdema and not the slightest sensitiveness to pressure on the mastoid process. The chiselling open of the latter disclosed a diffuse infiltration of the bone with discolored malodorous pus, and the sinus sigmoideus was filled with a yellowish, smeary mass. The middle ear was widely opened and the sinus laid bare and cut into until normal tissues were encountered.

Since three days after this extensive operation, many chills with rises of temperature to 42.8° C. (in the axilla) had set in, the vena jugularis communis was freely dissected in its entire course through the neck. It appeared as a flat strand of yellowish-gray color without pulsations. We followed it toward the thorax, and at the point where it runs under the clavicle, it appeared as a thick, blue vessel that filled and emptied itself synchronous with the movements of respiration. It was ligated at a point where it appeared healthy, and divided; from this point it was followed up to the base of the skull; it was then exposed, divided, and its open end drained with a strip of iodoform gauze. The examination of the specimen showed the border line between the septic thrombus and the normal wall of the vein (toward the thorax) very distinctly. The further course of the disease was very unfavorable; the patient died four days after the operation. While the rigors disappeared, the patient became very asthenic and a remittent fever continued.

The post-mortem examination showed that the septic thrombus found at the operation had been completely removed. In the portion of the sinus sigmoideus left behind as well as in the region of the jugular vein, a number of recent benign blood-clots were present. However, a smeary deposit was found in the jugular foramen. The cause of death was proven by the autopsy to be multiple metastatic abscesses in the lungs. The upper lobe of the left lung was almost completely gangrenous.

It is evident that the operation was performed at a time when the septic thrombi had already been carried to the lungs—hence too late.

Soft Thrombi

OBSERVATION X, 11

Acute Non-Suppurative Inflammation of the Middle Ear. Paralysis of the Abducens of the Right Side. Manifestations of Cerebral Compression. Partial Sinus Thrombosis. Cure Following Trephining of the Cerebellar Area.

A merchant, thirty-nine years of age, was treated by *Dr. Hans Röhr* for acute right-sided non-suppurative inflammation of the middle ear. After fourteen days the patient completely recovered. Three and a half weeks later (30th of May, 1910) pains in the back of the head toward the right side of the skull as well as a dull sensation of pain in the ear set in. Eight days previous to that time the patient had a severe chill which was followed by a rise of temperature to 38.5° C. From the 27th of May on, his morning temperature was 36.8°, and in the evening it was 37.4° C. Since the pains became more violent and the temperature remained the same, *Dr. Röhr* suspected sinus thrombosis, and on the 5th of June he chiselled open the mastoid process and exposed the sinus sigmoideus. The cells of the mastoid showed no inflammatory changes from the point up to the tegmen. The fairly deep and small antrum was also free. Neither did the tympanic cavity show any signs of inflammation. The exposed portion of the sinus offered a normal appearance; it was soft and evidently filled with blood.

The patient did not improve after the operation. He complained of pains about a hand's breadth above the right ear, over the entire parietal region on the right side. There were also persistent violent pains in the frontal bone and over the root of the nose. The examination of the nervous system by *Sanitätsrat Kron* showed nothing abnormal. The examination of the eyes (10th of June) by *Professor Greeff* disclosed the following conditions: The right conjunctiva was injected and a slight swelling surrounded the right eye. Slight optic neuritis without œdema. Some turgidity of the veins of the fundus oculi. Clear liquor free from bacteria and leucocytes was evacuated under moderate tension by lumbar puncture. On the 12th of June there suddenly set in diplopia as a result of paralysis of the abducens on the right side; this was accompanied by slight nystagmus. The pulse ranged somewhere between 60 and 80 beats per minute. The urine was free from sugar and albumin. The diagnosis was: Inflammatory process in the region of the nervus abducens, at the point where it crosses the sinus petrosus superior at the pyramid of the petrous portion of the temporal bone. Thrombosis was thought of, and abscess and serous meningitis were considered. I saw the patient on the 17th of June and found the following conditions: Total paralysis of the abducens; coarse nystagmus in the lateral position of the eyes and upon looking to the left. The abducens paralysis was limited to the left eye. Slight hyperæsthesia of the second branch of the trigeminus shown by pricks with the needle. Corneal reflex present on both sides. The right pupil was somewhat more sensitive to light than the left. Both acustici were intact and caloric nystagmus normal. The patellar reflexes were somewhat exaggerated. *Babinski, Oppenheim,* and cerebellar swaying absent. The pulse was at times strikingly fluctuating and would sometimes come down to 60 beats per minute; at other times again it would rise to 80.

Trephining over the right cerebellum was carried out on the 18th of June. On the night preceding the operation the patient became suddenly deaf and had a sensation as though the ear was stuffed up. The examination of the ear by *Dr. Röhr* showed, however, nothing pathologic. After the osteoplastic flap had been reflected, the dura cerebelli lay deeply sunken in the posterior fossa of the skull forming a flat trough. It did not pulsate. The dura covering the left cerebellum and the right occipital lobe (exposed to an extent of 4 cm.) were in the same condition. The sinus transversus appeared entirely empty and flat. I was able to feel a firm cord, the thickness of a goosequill, along the median side of the sinus sigmoideus down to the bulbus of the jugular vein. Toward the outer side of this cord the sinus was bluish in color and pulsated slightly, synchronous with the respirations. We were evidently dealing with a *partial sinus thrombosis.* The lateral partition of bone was now removed and a part of the dura of the temple exposed. It showed nothing abnormal. Since the sinus sigmoideus was seen to pulsate in its lower portion, we did not follow it beyond that point. At the moment when the tampon was removed from the injured emissarium mastoideum, a hole about 2 mm. in size was found in the sinus sigmoideus, from which not a drop of blood issued; a harsh noise was heard at each inspiration (air was entering it). The pulse at once became small and irregular, and the opening was immediately pressed upon with the finger. A strip of vioform gauze was placed against it. Soon thereafter the patient reacted. The wound of the mastoid was tamponed with vioform gauze and the osteoplastic flap sutured into position in the usual manner.

The patient withstood the operation well. His temperature fluctuated between 36° and 37.8° C.; it reached 38° a few times only. The pulse continued accelerated. About the 19th of June a slight improvement was noticeable in the right eye. At that time, however, disturbances of deglutition set in which lasted until the 24th of June. Nothing abnormal was found in the pharynx. The paralysis of the abducens gradually regressed, and on the 7th of July not a trace of it remained behind. At the request of the patient, he was discharged from the clinic on the 14th of July. At that time the findings were as follows: The reaction of the pupils and the corneal reflexes were normal and the right abducens functionated, as well as the left. There was no diplopia and no *Romberg* swaying. Moderate headaches continued until September and from that date on he complained of no subjective disturbances. The valve created with the trephine showed osseous union and was not depressed. The power of hearing was normal. On the 17th of November *Professor Greeff* made an ophthalmoscopic examination and found only a slight pallidity of the right optic nerve. Its outlines, however, were distinct, the circulation normal, and the visual power 5/5.

The important point in this interesting case brought out by *Dr. Röhr* in presenting the patient (who had completely recovered and had gained forty-six pounds) before the Medical Society of Berlin (May 24, 1911) was the insidious symptom-free progress of the mild inflammation of the middle ear and the difficulty of diagnosis between thrombosis, abscess, and serous meningitis. The formation of the thrombus in the sinus sigmoideus is remarkable, for the reason that it developed on the side opposite the ear, while the side toward the ear remained normal. The onset of the paralysis of the abducens gave us a clue to the seat of the trouble. Thrombosis of the sinus transversus may by itself cause paralysis of the abducens. On the other hand, thrombosis of the sinus petrosus superior is not necessarily followed by it.

Infectious Thrombosis in Other Inflammatory Processes and Suppurations

While suppurative processes in the region of the auditory apparatus are by far the most important and most frequent cause of infectious thrombosis of the various sinuses, any inflammation or infectious disease of the bones, soft tissues and cavities of the head, face, and neck may give rise to it. I shall cite an example.

OBSERVATION X, 12

Abscess in the Submaxillary Region. Thrombosis of Veins. Thrombosis of the Sinus Transversus. Trephining Followed by Splitting of Sinus. Permanent Cure.

A merchant, twenty-one years of age, free from hereditary taints, had suffered for some time from pains which radiated in the distribution of the occipital nerve, and from rigidity in the back of the neck. The attending physician made a diagnosis of tuberculosis of the atlanto-occipital joint. The pains, however, together with the rigidity of the neck soon disappeared, but in their stead, a swelling appeared on the right side of the neck indicating a deep-seated infiltration. This was accompanied by chills, the temperature was remittent, and the patient presented a picture of severe, general infection. On the 12th of February, 1898, an abscess was opened in the submaxillary region underneath the deep cervical fascia and a creamy pus evacuated. The vertebral column was intact. The temperature fell for one day, but soon rose to 39.4° C. On the 20th of February the wound was found granulating well, but a thrombosed vein was discovered in it. This was found to be the vena facialis communis which was resected. The examination of the vein disclosed no septic thrombosis. On the same day the processus mastoideus was chiselled open, because the patient complained of continuous pain in the process when pressed upon. Nothing pathologic was found and the examination of the middle ear showed also normal conditions.

After this operation, the fever remained high and markedly remittent and the pulse fluctuated between 116 and 124 beats per minute. The general condition of the patient became much worse, almost hopeless. Œdema of the right half of the face set in. A careful examination of the nervous system disclosed, outside of bilateral mydriasis with sluggish reaction of the pupils, nothing abnormal. The cerebral manifestations frequently observed in cases of sinus thrombosis (headache, sopor, vomiting, delirium, etc.) were absent. However, I decided to trephine the region of the right sinus transversus on account of the severe sensitiveness to pressure in this area. This sinus was exposed on the 28th of February, 1898. It had the appearance of a grayish cord that was very prominent and of firm consistency. The brain did not pulsate.

We followed the transversus up to a point where it enters the sigmoideus at the base of the pyramid of the petrous portion of the temporal bone. It was of a normal blue color and pulsating. The entire right sinus transversus was now split lengthwise, and the thrombosed mass, which was partly red and friable, and in part gray and firm, was removed with a scoop. The sigmoideus was now bleeding in a normal manner and it was tamponed with iodoform gauze. It was followed up medianward almost to the confluens sinuum where a white thrombus was found in it and its lumen contained some sanguineous fluid. In this place it was not of normal width, on the contrary, it was considerably constricted. A strip of iodoform gauze was introduced into this narrowed lumen also.

Even after the transverse sinus had been cleared of thrombi, the dura did not pulsate. The wall of the sinus facing the brain was therefore also incised longitudinally so that the surface of the brain now lay freely exposed. A considerable quantity of liquor cerebro-spinalis drained off, after which slight cerebral pulsations were noticed in the region of the confluens sinuum, while the brain toward the mastoid process showed no pulsations as yet. Two cerebral punctures were negative. The exposed portion of the brain was now covered with iodoform gauze and the whole wound filled with the same material.

The result of this operation was good. On the next day the temperature fell from 39° C. to normal and after that time it never exceeded 37.6° C.; while the pulse continued over 100 for a period of three weeks. The threatening general manifestations gradually receded in the first week after the operation and after some time the unilateral œdema of the face disappeared. The cerebral pulsations in the opening of the skull became more distinct, and after eight days they were visible in the lateral section of the wound.

Four weeks after the operation the patient left the bed, and in two more days he left the hospital, having gained six pounds. The wound had completely healed. A trace of œdema in the right half of the face could at that time still be demonstrated by pressure with the finger.

After that the patient completely recovered, and he is now able to follow his occupation without inconvenience. His brother, a physician, informs me of his complete restoration to health.

Rhinitic Abscesses

The causes that may lead to abscess formation of the brain, outside of traumata and suppuration of the ear, have been given above. However, of all these, I wish to cite an example of abscess resulting from suppuration of the nasal and frontal sinuses.

OBSERVATION X, 13

Acute Suppurative Frontal Sinusitis. Fall of Temperature After Chiselling. Fever Again. Large Extradural Accumulation of Pus. Abscess in the Frontal Brain. Five Days Later, Abscess in the Central Region. Death from Exhaustion.

A woman, twenty-three years of age with negative history, began to suffer on the 21st of November from violent, continuous headaches. Her temperature was at that time 37.7° C. On the following day the headaches became worse and a projection was visible over the left frontal eminence; temperature 38.4° C. On the 22d of November, the swelling had considerably increased in size and extended from the root of the nose over the entire supraorbital ridge and frontal bone to the borderline of the hairs. Temperature 39.6° C. On the 23d of November, the œdema had increased and it also involved the upper eyelid. Morning temperature, 40°; noon, 41.2° C. An otologist was consulted who at once opened the frontal sinus and about 1½ tablespoonsful of ichorous pus was evacuated. The opening leading into the nose was found closed. It was opened and drained. The frontal sinus was much enlarged, and was tamponed. After the operation the temperature sank to 36.4° C.; this was accompanied by rigors. The headaches ceased at once and the temperature remained normal for six days (36.4° to 37° C.). On the seventh day, the temperature rose again (40°) and despite the opening of a superficial abscess, it did not fall. Simultaneously a dry pleurisy developed on the left side.

At that time and until the 5th of December, there was no sign of meningitis, the subjective condition of the patient was good, the mentality clear, the movements of the head free and without pain, there was no vomiting, the abdomen was not retracted, etc. The temperature could be easily explained by a beginning pneumonia in the left lower lobe of the lung. On the 5th of December (morning) the temperature had gradually fallen to 38° C., but on the same afternoon the patient suddenly became unconscious and the fever mounted abruptly to 39.4°.

When I saw the patient on the evening of the 5th of December, she answered to all questions: "All right," and smiled. The left eye was a little more prominent than the right. Of meningeal symptoms, only a slight restriction of the movements of the head were noticeable. It appeared probable that the patient had developed an abscess in the frontal brain, but there could also be a septic thrombo-sinusitis, although there were no rigors since the 23d of November. The temperature was 39.4° C., and the pulse 104. She was operated on the same evening.

A pouting, granulating wound was found above the left eyebrow; it was covered with a smeary deposit; a hole admitting a finger led to the frontal sinus. The wound was enlarged by prolonging the incision of the eyebrow. The greater portion of the anterior wall of the sinus was removed; this permitted thorough inspection of all its parts. Laterally, on its floor, a fistulous tract admitting a medium sized probe was found in the bone; it extended 2 cm. in a lateral direction of the left temporal region in the lamina vitrea and was filled with pus. This was evidently the channel through which the *infection of the brain* took place. After ridding the frontal sinus of the smeary granulations, it was tamponed with vioform gauze. No pus was found in its recesses.

In order to expose the frontal brain, an osteoplastic flap was fashioned, the base of which was directed upward—corresponding to the hair-line (see Plate XLIV, Fig. b). As soon as the first hole was drilled in the upper median angle of the wound, thin, malodorous pus issued forth. Nothing was obtained from the other three apertures made. As soon, however, as the bone was resected and lifted off, a continuous stream of pus drained away—about half a wineglassful. The dura was not materially changed in the median upper half of the cleft, but showed here and there a yellow spot of pus, while, externally and below, it was covered with thick layers of purulent fibrin. A defect about 1 cm. in length was also found here through which pus was spurting at each cerebral pulsation. The osseous cleft was somewhat enlarged outward and downward, and the tear in the dura separated with a couple of *Péan* hooks. The walls of the abscess cavity were found covered with white fibrinous deposits. A stout drain about 4 cm. wide was introduced into that cavity. The supradural and the frontal lobe abscess cavities were now packed with vioform gauze and the trephined flaps reposited over them.

The result of the operation was at first satisfactory; the temperature fell to 37.5° C. and the pulse to 74 beats per minute. The somnolence subsided, the general condition of the patient became tolerable, and she slept well. The movements of the head became free and there were no signs of meningitis. On the 8th of December, however, a chill set in and the temperature rose to 38.9° C. and the pulse to 98. Inspection of the wound disclosed no retention of pus. Two days later a paresis of the right half of the body developed, which included the facialis, and an extension of the pus backward toward the central area was no longer doubted. This area was trephined and the arachnoid was found cloudy, but there was no suppurative meningitis. Puncture disclosed a subcortical abscess situated in the region of the anterior central convolution, which was filled with malodorous pus. The abscess was widely opened and drained. No extension of the suppuration was discovered while dressing the patient in the following three days; she failed however perceptibly. The temperature fluctuated between 38.3° and 39.3° C., and the pulse was about 120. She died on the 14th of December. An autopsy was not permitted.

Meningitis Purulenta

H. Kümmell advocated in suppurative conditions wide opening of the cranium, analogous to the practice in laparotomies for peritonitis.[1] He reports a case of severe meningitis in connection with a fracture at the base of the skull, in which pus was obtained by lumbar puncture. In this case he obtained a cure from double trephining.

After falling on the back of the head, the patient had become unconscious, after which vertigo, headaches, noises in the ears and difficult hearing on the right side had set in. It is stated that in the first days following the accident, a profuse watery fluid discharged from the nose. At the hospital the headaches became more intense, the sensorium became cloudy, and the temperature mounted to 40° C. To this, strabismus and rigidity of the back of the neck were soon added. Lumbar puncture, performed on the 2d of January, 1905 (on the ninth day after the accident) yielded a thick purulent fluid. As a last resort, the almost moribund patient was trephined on the 4th of January. Two openings were made, each the size of about half a dollar—one in each occipital region encroaching on the parietal bone. The dura was found very tense and it was split corresponding to the entire width of the cleft in the bone. The arachnoid was strongly injected and cloudy. Strips of gauze were introduced into both openings of the skull and they were projected into the posterior fossæ as far as possible.

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[1] *Hermann Kümmell,* Die operative Behandlung der eiterigen Meningitis. XXXIV. Kongress der Deutschen Gesellschaft für Chirurgie. 1905.

On the next morning the pulse was better, the temperature 38° C., and the sensorium less cloudy. On the second day after the operation, lumbar puncture still yielded a flocculent liquid which was perfectly clear on the sixth day. On the fifth day the patient was free from fever, and on the tenth day, his mental condition was normal. The disturbances in reading and writing gradually regressed. After gradual removal of the drains, the trephined wounds healed without complications. About the middle of February, the patient was discharged cured and he was able to resume his work.

In order that such operations be successful, they must be performed at the earliest possible moment. *Kümmell* reports another case of advanced severe meningitis in which he was able, by trephining and splitting of the dura, to obtain considerable improvement in the subjective condition of the patient without, however, averting a fatal issue. I have also had such experiences, but I have thus far been unable to bring a case of decided septic meningitis to recovery.

We find in the literature of recent years a number of cases of *circumscribed suppurative meningitis* in which the affected cerebral membranes were exposed. Almost all of these were instances of meningeal inflammations of otitic origin or the result of complicated fractures of the skull. *Lucæ* and *Jansen* have cured cases of suppurative leptomeningitis of the temporal lobe consequent to otitic processes by splitting the dura and drainage. *Bertelsmann* was successful in bringing about a cure by trephining a case of otogenous meningitis in which lumbar puncture yielded a turbid fluid. In his thorough work on suppurative diseases of the brain and spinal cord, *Mac Ewen* speaks of 12 cases of circumscribed purulent leptomeningitis, of which 6 were cured by operation. Of these, 5 affected the middle, and 1 the posterior region of the skull. *Kümmell* also accomplished cures in three patients suffering from otogenous suppurations, who presented a picture of severe meningitis, by extensive trephining of the temporal bone and splitting the discolored dura.

There is a general consensus of opinion that cases of circumscribed otogenous meningitis should invariably be trephined, the dura widely opened and the pus drained. This should be preceded by opening the middle ear and, if needs be, of the labyrinth.

The greatest difficulty in these cases is the diagnosis which should be made early, aided if necessary, by repeated lumbar punctures. The patient should be operated on at the earliest possible moment. If the fluid obtained from lumbar puncture be turbid and contains numerous pus cells, an immediate operation is urgently indicated even though the other symptoms of suppurative meningitis be not as yet pronounced. It is assumed, of course, that there exists labyrinthine suppuration. The underlying principle of the operation consists of exposing the dura and splitting it along the pyramid, beginning at the sinus sigmoideus and ending at the porus acusticus. If the suppurative turbidity of the liquor be occasioned by an uncomplicated cerebellar abscess, the error will be discovered as soon as the dura is opened, and even then the procedure would do no harm because the operative modus in both instances is practically the same. *Wittmaack*[1] reported two cases of beginning suppurative meningitis consequent to cholesteatoma and labyrinthine suppuration, cured by operation.

Circumscribed meningitis, resulting from complicated fractures of the skull, should be treated in the same manner, supplemented, if needs be, by removing of necrosed and destroyed portions of brain. *Witzel* was successful in curing a patient in whom a progressive meningeal phlegmon was caused by splinters resulting from an accident.

However, in *diffuse suppurative meningitis,* conditions are much different. The question whether these cases should be treated surgically at all, is not as yet settled. Only a few of such cases are to be found in the literature. *Poirier* cured his patient, suffering from diffuse meningitis, the result of a fracture of the skull, by double trephining. *Witzel* saw meningitis develop in connection with a fracture of the base of the skull with bleeding from the right ear. After exposing the right temporal lobe, splitting the dura, and tamponade, the meningitic manifestations gradually receded and the patient recovered. *Mac Ewen* operated five times for diffuse cerebro-spinal leptomeningitis. One patient recovered.

We will decide to operate in otitic suppurations, under all cir-

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Wittmaack, Über die operative Behandlung der eiterigen Meningitis bei Labyrintheiterungen. "Münch. med. Woch.," 1908, No. 47.

cumstances, when, as in the following case, the clinical manifestations point to an abscess of the temporal lobe.

OBSERVATION X, 14

Manifestations of Abscess of the Left Temporal Lobe. Operation Uncovers Suppurative Meningitis. Autopsy Shows also Encephalomalacia of the Right Temporal and Frontal Lobe. Microscopic Examination Reveals Inflammatory Separation of the First Left Temporal Convolution, the Region of the Island of Reil, the Putamen and the Internal Capsule.

The patient, a man twenty-five years old, suffered for a long time from headaches and a discharge of pus from the left ear. Soon after his admission to an institution for the treatment of nervous diseases (February 28, 1906), a somnolent, stuporous condition set in, which persisted throughout the disease and became more intense toward the end. At times the patient was conscious, but most of the time his mental condition was so fogged that he lay listlessly, and the functions of his rectum and bladder were involuntary. Besides this, the following disturbances were added to the clinical picture: Drooping of the left angle of the mouth; weakness of the right arm and especially of the right lower extremity with exaggerated reflexes; disturbances of speech, i.e., optic-tactile paraphasia with good repetition of words and retained understanding; no disturbances of reading and writing; left otitis media purulenta (cholesteatoma?), later on, also considerable pains in the right ear and hyperæmia of the right ear-drum. Toward the end of the disease, which lasted about two or three months, there were rises of temperature (39.2° C.). The other symptoms were indistinct and transient.

Based on these symptoms (weakness of the right extremities, disturbances of speech, left otitis media purulenta, pyrexia), a diagnosis of abscess of the left temporal lobe was made and on the 9th of May the patient was referred to me for operation. He was trephined on the same day, and the left temporal lobe was exposed (compare Plate XLV) by a flap with upper base; the bone was preserved. The left posterior fossa of the skull

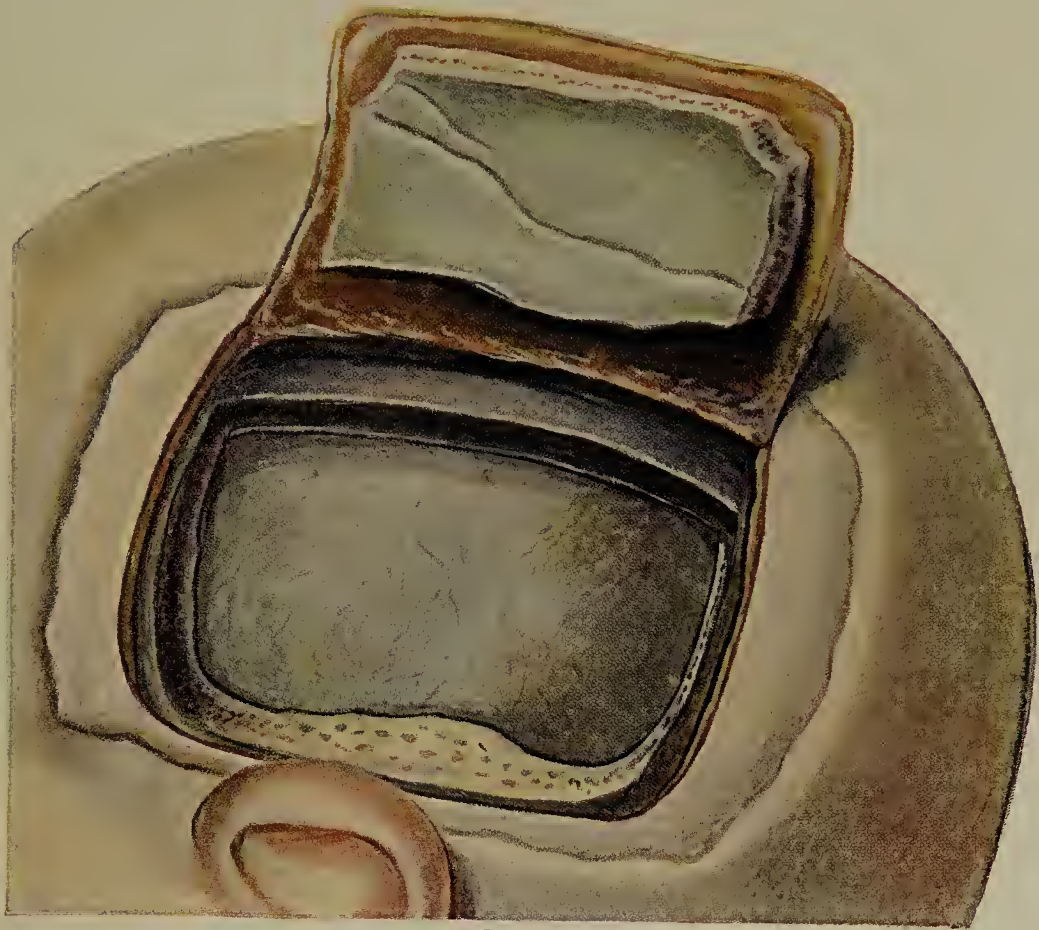

Fig. a.

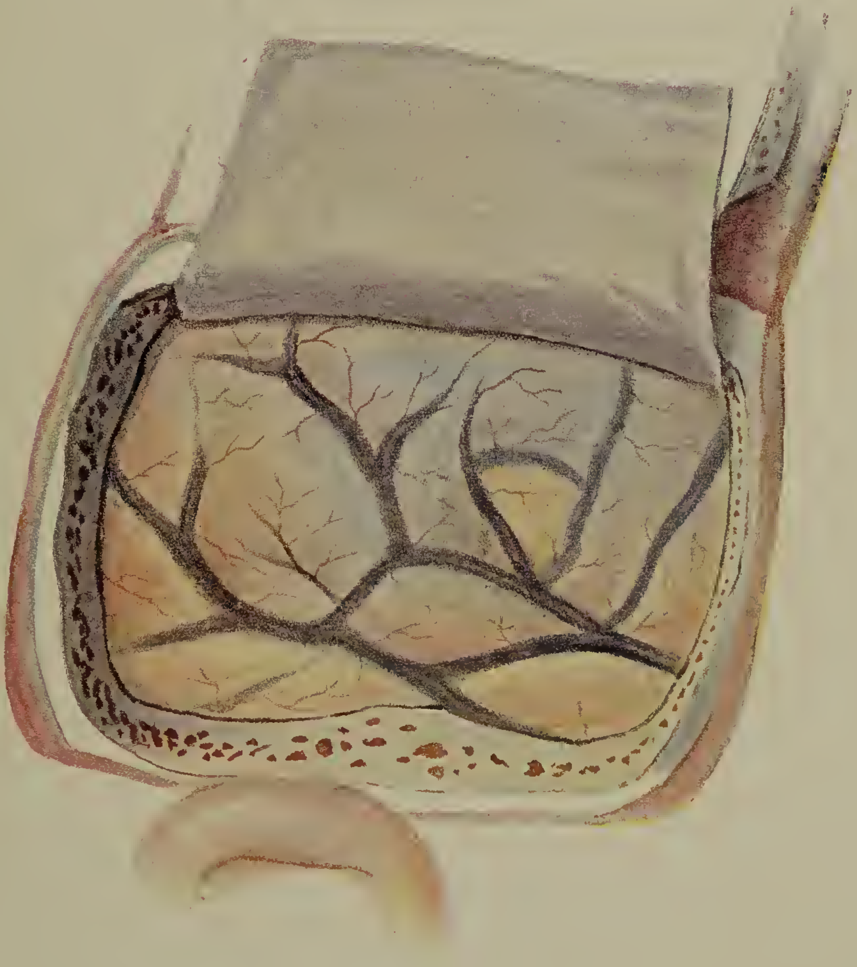

Fig. b.

Rebman Company, New-York.

was made accessible by widening the cleft in the bone backward. The arachnoid and pia showed characteristic changes of a beginning suppurative meningitis. The findings were otherwise negative (especially with reference to abscess). After the operation the coma became more profound, it interchanged with states of excitement, and on the 11th of May the patient died.

The post-mortem examination revealed a bilateral meningitis of the convexity and encephalomalacia lobi temporalis et frontalis dextri. Microscopic examination of frontal sections of the brain *(Dr. L. Jacobson)* showed an inflammatory separation of a large portion of the first left temporal convolution, the adjoining portion of the island of *Reil,* the putamen, and the internal capsule. These foci explained the clinical manifestations of paraphasia and the paralysis of the right extremities. An extensive cortical encephalitis which embraced the entire temporal lobe and the third frontal convolution was found on the right side. The same changes were found in the adjoining sections of the parietal lobe and the central convolutions. These foci were responsible for the weakness in the left lower facialis region.

This observation is very instructive for the reason that the autopsy *in vivo* as well as the post-mortem examination showed that a wrong diagnosis had been made. The microscopic examination showed the exact state of affairs. The parts of the brain suspected of being involved (sensory centre of speech and left pyramidal tract) were found affected, but not in the manner thought of. We are at the present time not in a position to be able to decide beforehand whether we are dealing with a case of meningo-encephalitis or with an abscess.

Metastatic Processes

Metastatic Carcinoma of the Brain

Primary carcinomata of the brain are extremely rare. They originate from the epithelium of the chorioid plexus of the ventricles and assume the form of papillomatous structure. The rarest variety is that springing from the ependyma of the cavities of the brain. From a clinical point of view these tumors are not significant (at least surgically) because they are so deep-seated that they cannot be reached, and a certain diagnosis of their existence has thus far not been made.

Metastatic carcinomata, on the other hand, are not infrequent; they mainly affect the cerebral substance, and may be multiple. They are principally secondary to carcinomata of the breast, the thorax, the lungs, or the bronchi, and occasionally also to carcinoma of the ovary. A peculiar analogy exists here, in that metastatic abscesses of the brain are principally observed in connection with suppurations in the thoracic organs. The same anatomic factors must therefore be operative in both metastatic conditions. In one instance the cancer-cells, and in the other, pus-producing organisms are carried away. This analogy deserves mention.

The following case is an example of metastatic carcinoma of the brain.

OBSERVATION XI, 1

Old Carcinoma of the Right Breast. Metastatic Tumor-Mass in the Posterior Section of the Right Frontal Brain. No Operation.

The patient was fifty-one years of age and underwent an operation three years ago for cancer of the right breast, and two years later, for a recurrence of the same trouble. A few weeks

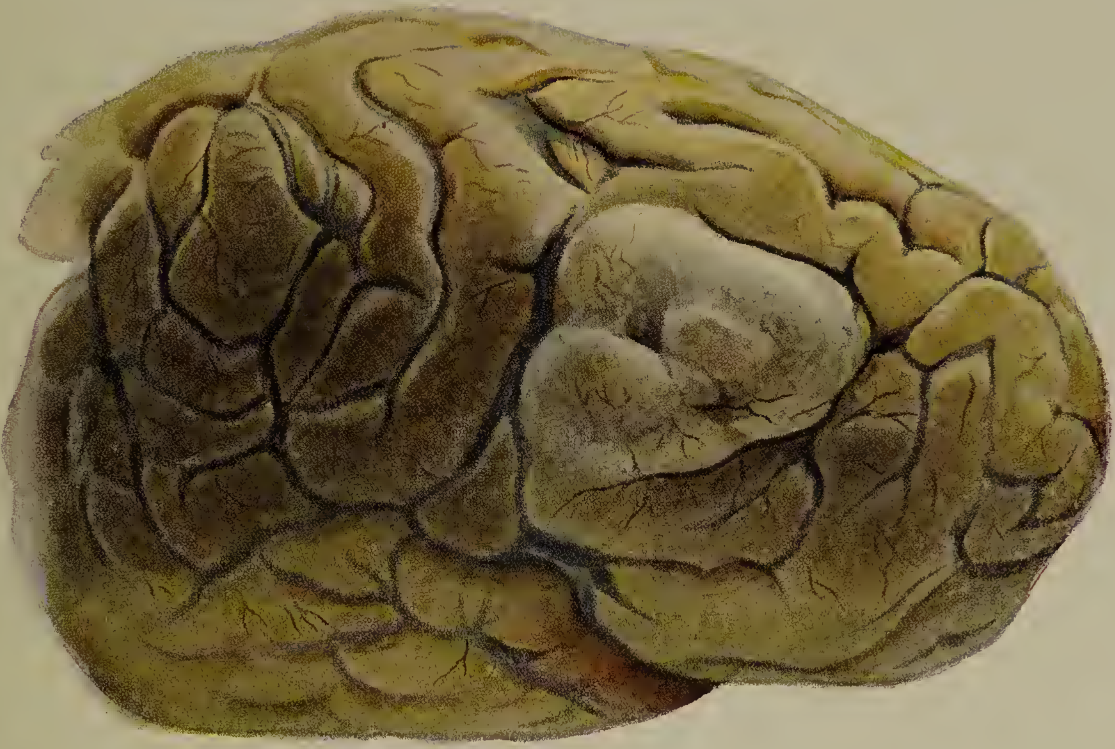

Fig. a.

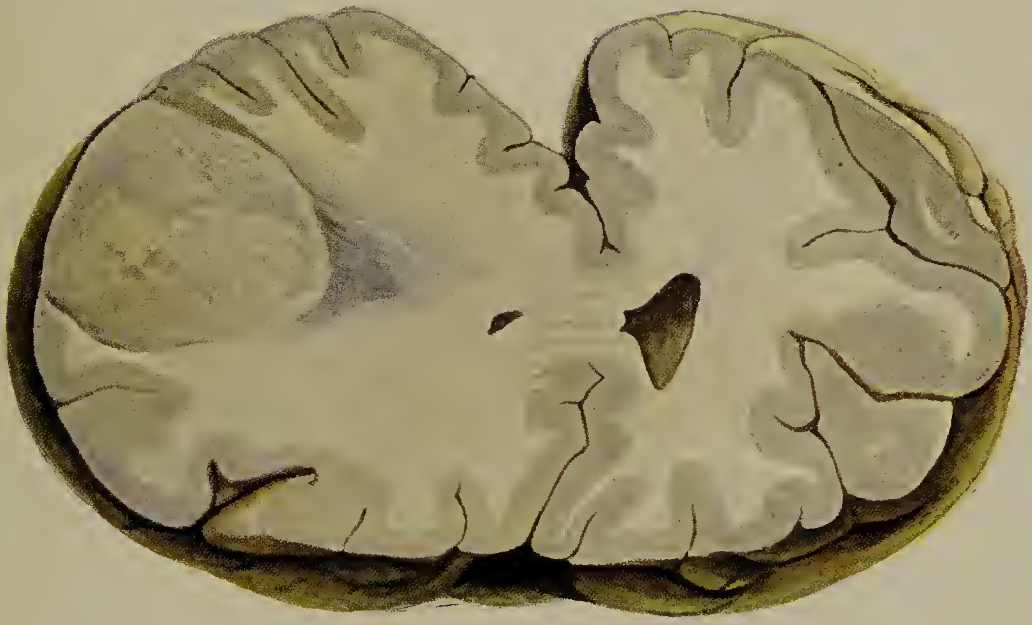

Fig. b.

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prior to her admission to the hospital she again began to complain of pains in her right chest. Her speech was somewhat retarded and her mental activity diminished. On the 8th of October sudden somnolence set in. She was admitted to the Augusta Hospital on the 11th of October in a semicomatose condition; she did not respond to calls, and it was difficult to feed her because she refused to take nourishment. Her pulse was 60 per minute, strong, full and regular. There was no vomiting, but the patient complained of headaches, and there was a marked choking of both discs. The pupils reacted to light, and the corneal reflex was present on both sides. Her face was peculiarly masklike and immobile. There was a left-sided facial paresis of slight degree, but no other nervous symptoms. The right breast was amputated. The sub- and supra-clavicular as well as the cervical glands of the right side were as hard as stone and very swollen. The lower border of the liver was hard and extended about two fingers below the costal margin.

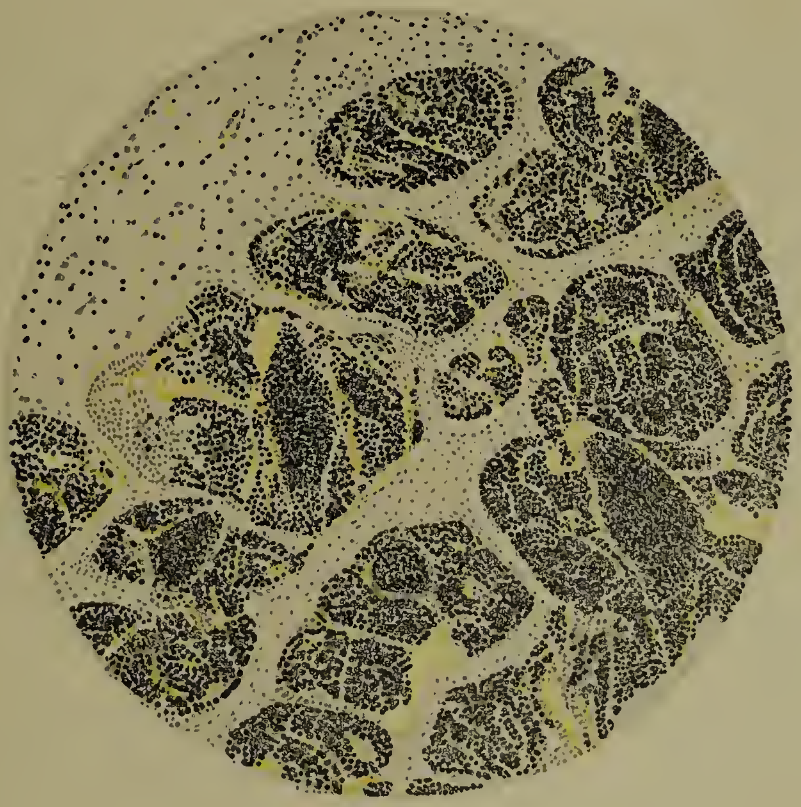

Fig. 147

Magnified, 70 : 1

Metastatic Carcinoma of the Frontal Lobe Following Carcinoma of the Breast

After a few days the condition of the patient improved and at times she was perfectly rational. She spoke in a whisper and could therefore not be understood well. Periods of aggravation, lasting about two hours, were of frequent occurrence. The coma became more profound and she evacuated her bladder and rectum involuntarily. The diagnosis was: Metastatic carcinoma of the right frontal brain. No operation was suggested. On the 9th of November the patient suddenly died.

The post-mortem examination showed carcinomatous infiltration of the right pectoral muscles, the subcutaneous fat and the anterior mediastinum. The pleura costalis showed flat, grayish-white cancer nodules, and the liver was constricted, but microscopically free from metastases. A protuberance, the size of a half dollar, was found in the brain immediately in front of the anterior central convolution in the region of the gyrus frontalis inferior and in the area of the arteria fossæ *Sylvii.* This place appeared white in color, intimately blended with the pia, and its surface was covered with brown spots (compare Plate XLVI, Fig. a). The vessels of the surface of the brain were arranged circularly around the tumor-mass and distributed small branches from the periphery to the centre. The surface of the tumor itself did not show any vessels.

Frontal section of this area (Plate XLVI, Fig. b) showed a medullary tumor projecting into the middle third of the right cerebral hemisphere. It filled out the hemisphere through the cortex and extended into the radiations of the corpus callosum like a wedge with rounded point. The gray substance terminated close to the base of the wedge. The signs of displacement were very well developed. Through displacement of the lateral wall, the right anterior horn was firmly closed; the left horn, on the other hand, was dilated and widely gaping. The median cerebral fissure was displaced about its middle (to the left) to such a degree that the entire left hemisphere appeared compressed.

The microscopic specimen (*Chief Physician Dr. E. Heymann*), depicted in Fig. 147 on page 903, shows under low power a series of large cancer nests within the glia tissue of the brain. The nests were traversed by wide connective-tissue lymph-spaces between which the epithelial cell-masses were deposited. High power magnification showed the characteristic cell arrangement of gland tissue *(adenocarcinoma).*

The analogy of this case to abscess was shown by the fact that not a single metastatic focus was found in any other organ and that the region of the arteria fossæ *Sylvii* was preferred. Despite the close proximity of the tumor to the central region, motor disturbances were remarkably few.

Operation on Metastatic Carcinoma of the Brain

Until now an inflexible rule was adhered to, i.e., not to operate on metastatic carcinomata of the brain. Such rules remain in force until clinical experiences overthrow them. I shall cite in this connection the following remarkable case.

OBSERVATION XI, 2

Successful Extirpation of a Neoplasm of the Right Central Region that Developed as an Adeno-Carcinoma. No Demonstrable Primary Cancer. Five Months of Comparative Well-Being. Death from an Intra-Thoracic Tumor.

A woman, sixty-three years of age, who had never been ill before and had not suffered from lues, became ill about four months ago (November, 1909) with manifestations of paralysis of the left arm which appeared first when the patient was combing her hair. Simultaneously a slowness of speech was observed without the appearance of real aphasic disturbances. The paresis of the left arm and forearm gradually became worse and the general condition of the patient as well as the state of her nutrition declined. In January, 1910, *Jacksonian* spasms occurred in the left arm which were occasionally limited to the hand. Outside of an œdema of the hand and a slight venous hyperæmia of the fundus oculi, no other morbid manifestations could be demonstrated. In February the attacks became severer, the patient was very weak and complained of increasing headaches in the frontal and occipital region, and of insomnia.

An examination, made in the beginning of March by a neurologist (*Dr. Löwenthal,* of Braunschweig) and *Professor L. Bruns,* of Hannover, disclosed an almost complete paralysis of the left arm with moderate œdema of the hand. The periosteal and tendon reflexes were exaggerated. The patient complained of severe pain in the joints on passive motion. Outside of slight disturbances of the sense of position of the left arm, no other sensory disturbances could be demonstrated. The left facialis and the left lower extremity were somewhat paretic, and spastic symptoms with slight reduction of the sense of position accompanied these manifestations. Outside of the increasing headaches, no other signs of a space-restricting process within the skull could be found. A diagnosis of neoplasm of the right central region was made and an operation recommended.

The first stage of the operation was performed on the 14th, and the second on the 23d of March, 1910. At the first incision through the dura on the side of the sinus, a grayish-red tumor-mass appeared on the convexity of the brain, but the neoplasm was in no way connected with the inner surface of the dura. After forming a flap of dura mater and reflecting it, a grayish-red tumor, about the size of a half dollar, was found projecting somewhat above the level of the anterior central convolution. A stout vein coursed along the posterior border of the tumor, which showed isolated yellow spots toward its front and middle portion. The entire tumor projected into the medullary substance, and it was enucleated with the finger from the surrounding brain substance, leaving a deep trough behind which, in the further course of the operation, filled in again. Only the finger could be used in enucleating this mass, because its consistency was only a little firmer than that of the cerebral substance. Anteriorly and above, two bleeding vessels leading to the tumor had to be ligated. Since during the operation tenacious masses of liquid consistency of a turbid yellowish-gray color were evacuated, the arachnoid space toward the sinus and the front was packed with vioform gauze to protect it from infection. After the enucleation was completed and the tampon removed, the normal dura was reposited over the flat cavity in the brain. The osteoplastic flap was now sutured into position without drainage.

The largest diameter of the tumor after its enucleation and the removal of the friable masses, was 36 mm., and the thickness of its wall, 6 mm. Its contents were a tenacious fluid, yellowish and intermingled with friable pieces. The inner surface of the capsule appeared nodular, warty, and covered with a stringy mucus. After the tenacious mucus was wiped off, the grayish-red warts appeared. They were only slightly harder than the surrounding normal cerebral substance, and they were everywhere permeated with sulphur-yellow specks. The picture was that of one of the forms of synovial tuberculosis. Slightly softened medullary substance of the brain covered the outer surface of the tumor sac. The external surface showed everywhere spherical nodules of a glassy appearance with fine, yellow spots.

The microscopic examination *(Professor Dr. Oestreich)* showed the structure of the tumor to be partly glandular and in part composed of solid cell-masses. The stroma was meagre and in numerous places infiltrated with small round cells. The epithelial cells of the glandular tubes were mainly of the cylindrical variety, regularly arranged in layers. The diagnosis was *metastatic adeno-carcinoma.* Such tumors are never primary in the brain. In this case there must have existed an occult primary carcinoma somewhere in the body, because repeated careful examinations failed to disclose the presence of such a tumor anywhere. In the further course of the disease the seat of the primary trouble was located.

The patient withstood the operation well. Her pulse and temperature showed no peculiarities, and the healing of the wound was normal so that the sutures were removed during the first change of dressings on the twelfth day after the second stage of the operation. The headaches completely disappeared, she slept well, her appetite was good and she became stronger. Two days after the removal of the tumor, active movements were possible with the left lower extremity. These became gradually stronger, so that fourteen days after the operation the movements in this limb could be executed with full power and just as good as with the limb of the opposite side. Disturbances of sensibility and of the sense of position did not exist.

In the beginning, the patient complained of sticking pains in the left arm, which soon disappeared, however. Eight days after the operation (April 1st) active movements were possible in the hitherto paralyzed left arm, i.e., first pronation. and then supination of the forearm. Two days later, flexion and extension of the elbow-joint could be performed, and on the 6th of April the patient could move her fingers. Later on, the mobility of the left arm, its circumference and power, steadily improved. On the 10th of April (eighteen days after the operation) the patient left the bed for the first time and she attempted to walk. Three and one-half weeks after the operation she was able to walk unsupported and departed for home.

For months it was reported that the condition of the patient was very favorable. Outside of a slight paresis, which did not interfere with the left arm, she enjoyed perfect health. In the beginning of September, however (after five months), tumor-masses were discovered in the supra-clavicular lymph glands and the patient complained of a dull, deep-seated pain in the region of the left shoulder-blade. Her attending physician made a diagnosis of probable intrathoracic tumor. The patient now rapidly lost her strength, and on the 12th of September she expired. It is said that a few days before the end, a rapidly growing tumor-mass developed in the region of the centre of speech (?).

We were dealing in this case with a metastatic condition, because primary adeno-carcinomata of the brain are unknown, especially in the central region. This woman (sixty-three years of age), who was kept in bed by the paralysis for a long time, was remarkably improved by the operation. This observation teaches that even cases of metastatic cancer of the brain with severe symptoms of cerebral pressure and paralysis will occasionally be benefited by a palliative operation. It is known that certain carcinomata are of very slow growth, and we also know that cancer of the stomach (histologically proven) will lead to the death of the patient only after five or six years after gastro-enterostomy. In the case just described the metastasis had in all probability travelled from a primary focus, which remained latent in the thorax for a long time.

Metastatic Tumors all Over the Body

The following observation teaches how extensively metastases may involve the entire cerebrum and cerebellum or even the whole body.

OBSERVATION XI, 3

Clinical Manifestations of Tumor in the Posterior Fossa of the Skull. Death in Collapse After the First Stage. Necropsy Shows Disseminated Endothelioma Over the Cerebrum, Cerebellum, and the Entire Body.

In October, 1906, the patient, a man forty years of age, began to complain of difficulty in speaking and of a sense of pressure in the head. Headaches, swaying, and violent vomiting gradually developed. The appetite declined and he could not eat on account of difficult deglutition. His walk became extremely uncertain. After his admission to the hospital (April 30, 1906) the patient lay in bed apathetic and quickly tired when speaking. He was unable to sit up, and when attempting to walk or stand, he invariably fell to the left side. The left occipital region was sensitive to the touch. There existed a marked choking of both discs with old and recent hemorrhages. The left abducens was paralyzed. All other ocular muscles were free. The left facialis was also paretic and the hearing in the left ear reduced. The left velum palati was hanging down, the left cucullaris was entirely paretic, and the left half of the tongue was atrophic and deviated to the left on protrusion. The sensibility of the entire body was retained. The right extremities were weaker than the left, and the muscles of the right hand were atrophic as compared with the left. Both patellar reflexes were absent. Occasionally the *Oppenheim* reflex could be demonstrated in the right lower limb.

Oppenheim made a diagnosis of neoplasm in the left posterior fossa of the skull with compression of the medulla and the pons from the left side.

On the 9th of May, 1907, the region of the left half of the cerebellum was trephined. The dura was found very tense, bulging and without pulsations. The patient collapsed and did not react. Twenty-four hours later he died.

At the necropsy *(Professor Dr. Oestreich)* all organs of the body, especially the serous membranes and the parenchyma of the lungs, were found studded with small, isolated and confluent

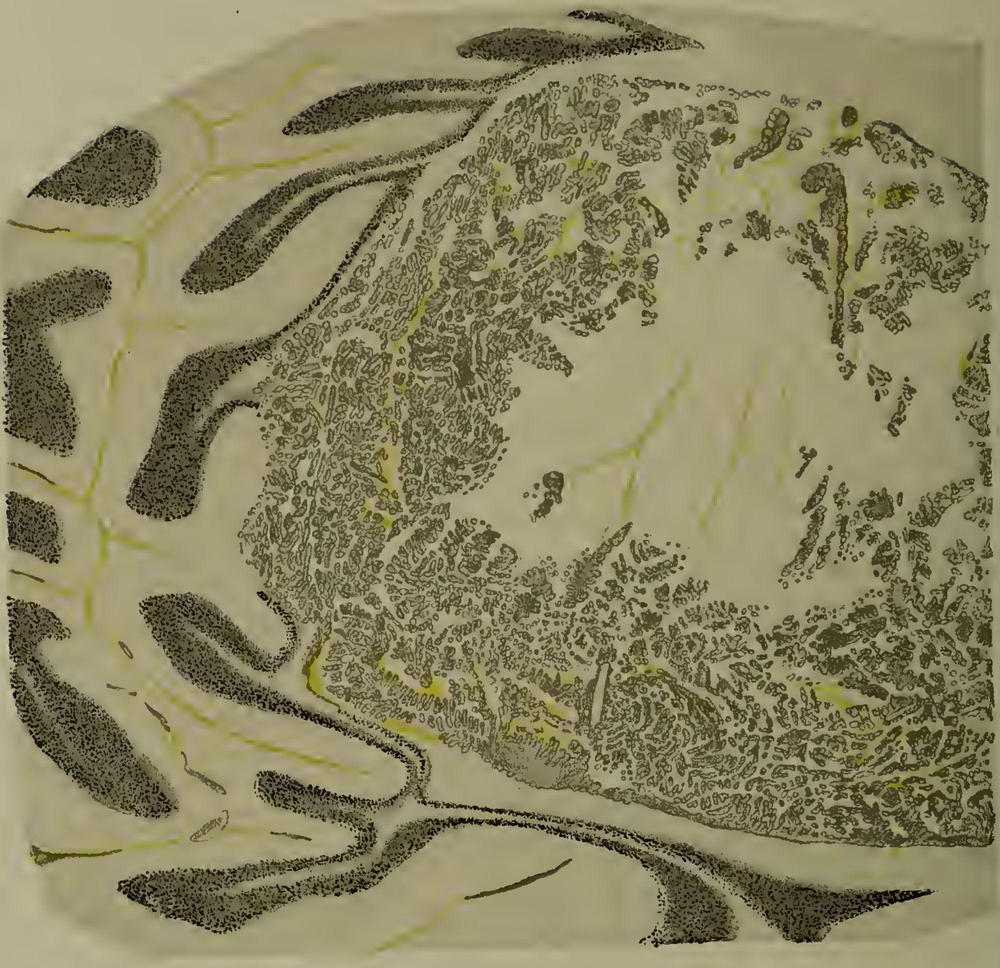

Fig. 148.—Magnified, 20 : 1.

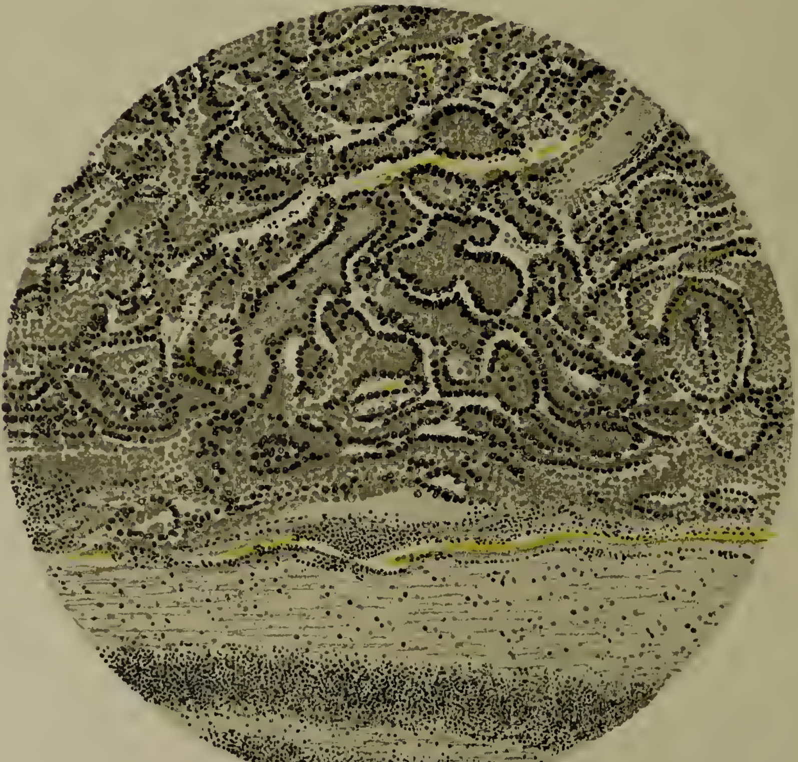

Fig. 149.—Magnified, 105 : 1.

cheesy foci. The largest of these was the size of a lentil. Ablation of the dura mater showed that the surface of the cerebellum and the cerebrum as well as cross-sections of the brain were studded with dry, irregularly distributed cheesy foci, ranging in size from that of the head of a pin to the size of a hazelnut. A diagnosis of miliary tuberculosis was made. The microscopic examination of these foci, however, showed them to be endothelial tumors and not tubercles.

Further section of the hardened brain showed, besides a slight hydrocephalus internus, that not only the gray matter but the entire white substance and the large nuclei as well were permeated by cheesy nodules ranging in size from a pea to a hazelnut. The frontal brain was generally free from these nodules which increased in number the farther back the sections were made. The right occipital pole and the pulvinar thalami optici were destroyed by cheesy masses the size of a large hazelnut. The cerebellum was more affected than the cerebrum and the left half more than the right. In the former, two caseous foci, each the size of a hazelnut, were found, and in the latter a somewhat smaller focus was present (see Plate XLVII, Fig. c). A caseous conglomeration was found at the base of the brain between the pons and the medulla oblongata.

The microscopic examination *(Chief-Physician Dr. E. Heymann)* showed the following conditions:

Fig. 148 shows one of the many cheesy nodules that were disseminated throughout the brain, and which ranged in size from that of a miliary tubercle to the circumference of a stone of a cherry. The cortical gray-matter was pushed aside during the growth of the newformation. A wide necrotic area was found in the centre of the nodule; cellular elements were present at the border only. Cells with large, oval nuclei lined the numerous interwoven and branching lymph-spaces closely resembling glandular parenchyma (see Fig. 149). Outside of these endothelial layers, connective tissue bands infiltrated with small round cells were present. The interstitial connective tissue of lighter color with deep stained nuclei of the outer layers (see figure above) recalled the picture of tubular carcinoma. However, it could easily be demonstrated that the specimen was not composed of glandular tissue, but that all clefts and large lymph-spaces were in close connection with each other. The condition must therefore be labeled as one of multiple or metastatic

Caseous Lymphangio-Endothelioma.

For the sake of completeness it should be mentioned that actinomycosis of the brain may also give rise to pseudo-tumors which *Bollinger* has described as

Actinomycomata;

of which only two instances have been reported.

Metastatic Carcinomata of the Dura

While rare, metastatic carcinomata of the dura are, nevertheless, met with. If the primary carcinoma does not produce any manifestations, we will believe that we are dealing with a perforating sarcoma of the dura.

OBSERVATION XI, 4

Exposure of a Supposed Perforating Sarcoma of the Dura Mater in the Region of the Occiput. Operation Interrupted on Account of the Close Proximity of the Confluens Sinuum. Death from Pneumonia. Post-Mortem Examination Shows Carcinoma of the Lesser Curvature of the Stomach.

In 1894 a woman, sixty years of age, observed difficulty in swallowing, that was mainly perceived at the root of the tongue. The report from the surgical clinic tells us that half of her tongue was at that time resected. The patient remained well thereafter. In March, 1906, she began to complain of gastric disturbances to which she was subject from early childhood. In August while combing her hair, she discovered a tumor, the size of a phalanx of the thumb, in the region of her occiput. She was at that time under treatment for stomach trouble at a polyclinic, whence she was referred to the surgical depart-

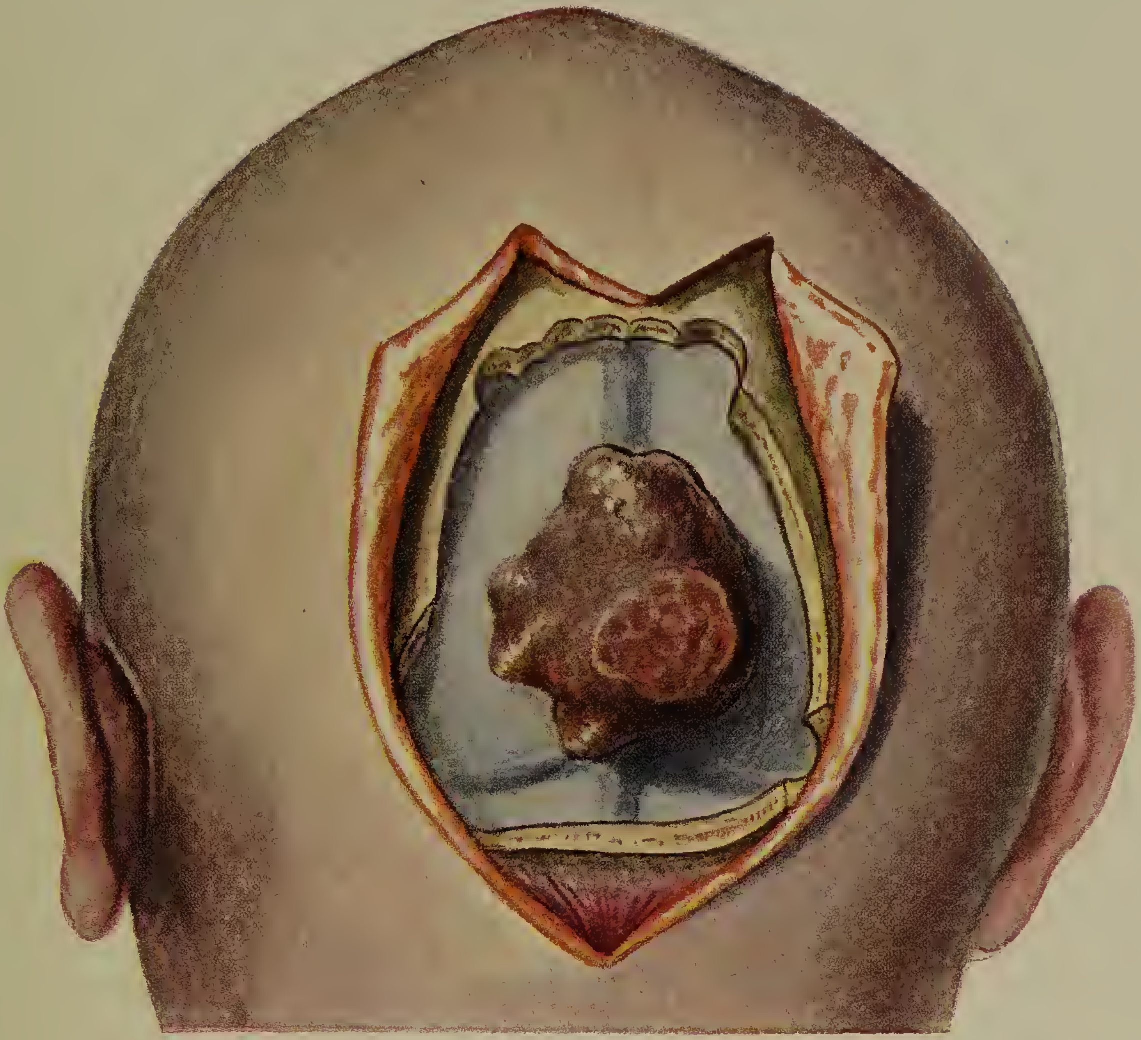

Fig. a.

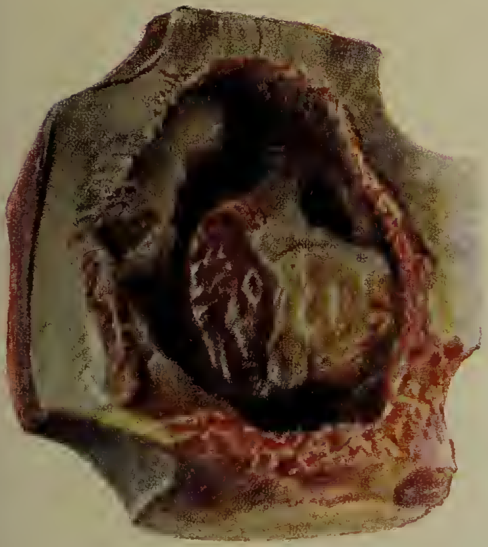

Fig. b. (Maßstab $^1/_1$)

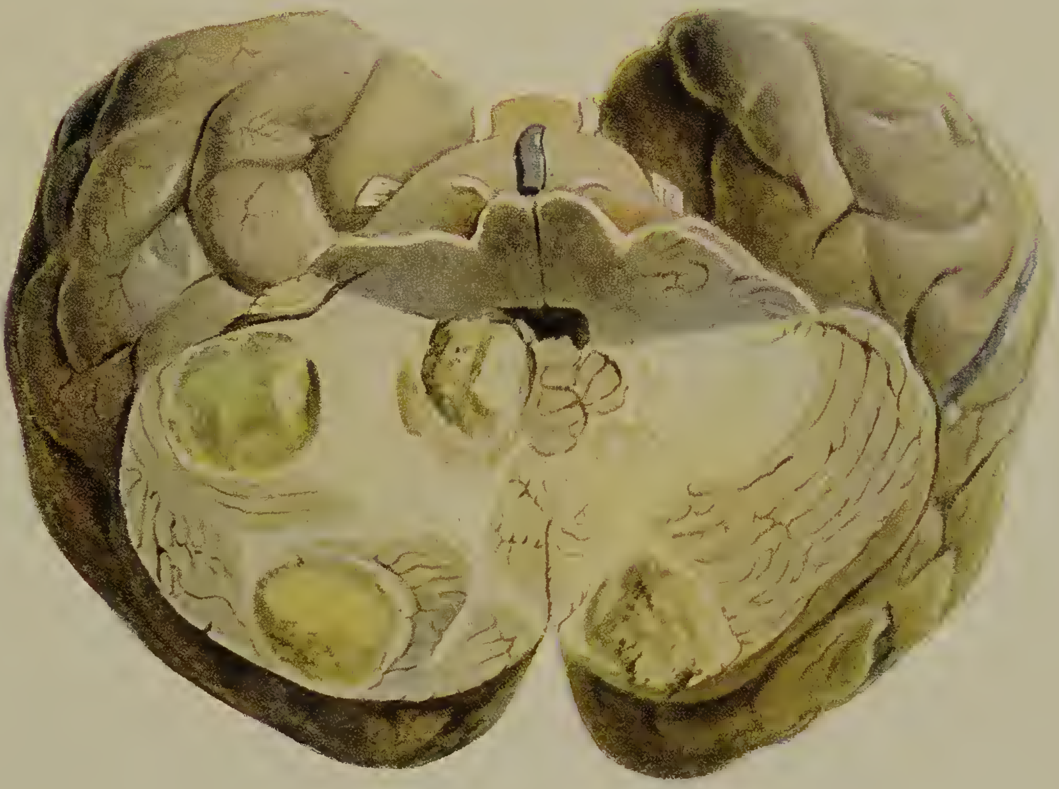

Fig. c.

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ment with a diagnosis of atheroma of the skin of the head. On account of the evident fluctuation of the tumor and on account of its mobility, the skin was split. Since a profuse hemorrhage resulted and since the contents of the tumor were not those of an atheroma, the patient was referred to the Augusta Hospital.

Outside of the scar of the tongue resulting from the previous operation, a painful point of pressure in the region of the lesser curvature of the stomach and a slight emphysema with bronchitis, nothing abnormal could be found in the patient. She had no cerebral manifestations; the movements of her eyes were free and the visual fields normal. The ophthalmoscopic examination was negative. Based on this symptomatology a diagnosis of perforating sarcoma of the dura of the occiput was made. The long time that had elapsed since the operation on the tongue (twelve years) spoke against metastatic carcinoma. The report from the department of internal medicine of the Polyclinic stated that the existence of neither carcinoma of the stomach nor any other internal disease was demonstrable.

The tumor exposed by the skin incision was about the size of a phalanx of a thumb. It was doughy in consistency and freely movable. On the 5th of October, 1906, the neoplasm together with the bone surrounding it were removed. A plate of bone of almost quadrangular shape was resected, and an eroded cavity, the size of half a dollar, was found on its dural surface. This cavity was filled with proliferated tumor-masses springing from the dura (compare Plate XLVII, Figs. a and b). The four limbs of the sinuses confluing to the torcular *Herophili* could distinctly be recognized on the dura. The tumor was situated immediately above the crossing of the sinuses. Since this exposure showed that in order to completely extirpate the tumor it would be necessary to attack the confluens sinuum and the sinus rectus and keeping in mind my experience in Observation VI, 4, p. 661, I decided to abstain from further operating in this case. The microscopic examination proved the tumor to be a carcinoma. This in itself was a contra-indication for any further procedure. Sixteen days later pneumonia set in to which the patient succumbed.

Autopsy *(Professor Dr. Oestreich)* showed the sinus longitudinalis filled with reddish-gray, dry thrombi (the transverse sinuses were free), the dura somewhat tense, the gyri flat and pale and the arachnoid delicate and transparent. The external surface of the dura presented the tumor exposed by the trephine. It did not involve the inner surface of the dura. The posterior part of the right half of the tongue was disfigured by a scar, and a portion of the tongue was removed. No metastases or enlargement of the cervical lymph-glands. Pneumonia of both lower lobes. The stomach was contracted, almost empty. On its posterior wall, near the lesser curvature and the pylorus, a medullary tumor of soft consistency, the size of a cherry, was discovered. The retrogastric lymph-glands were enlarged and hard. The mucous membrane of the stomach was grayish-red and softened in parts.

Diagnosis: Carcinoma of the stomach. Metastases in the lymph-glands and dura.

Metastatic Abscesses of the Brain

In 1853 *Virchow* was first to point out the fact that metastatic abscess formation in the brain is (analogous to carcinoma) remarkably frequent in connection with primary suppurative diseases of the thoracic organs, especially the lungs. This was frequently corroborated by other observers. In *Gower's* "Handbook on Diseases of the Nervous System," we find the total number of metastatic cerebral abscesses to be 15%. *A. Young*[1] reports 52 cases with 13 metastatic abscesses, while in 86 cases spoken of by *R. Meyer*[2] cerebral abscess was caused by suppuration of the lungs twelve times. Occasionally a focus of pus in any part of the body may be the cause of such embolic condition. Those cases are reported that have developed in connection with purulent pericarditis or suppurations in the abdominal organs, especially the liver. Occasionally phlegmons, suppurative periostitis, suppuration in the joints, panaritia, umbilical suppurations and complicated fractures may also be the cause.

I recall the case of a man forty-two years of age, who developed in connection with an attack of acute nephritis an abscess, the size of a hazelnut, at the base of the brain in the region of the clivus *Blumenbachii.* These exceptional cases form, of course, only a very small percentage compared with the usual conditions that give rise to metastatic abscess formation; i.e., primary suppuration in the endothoracic organs. Outside of cerebral abscesses caused by otitic, rhinogenous, or local septic processes, the most important cause for cerebral metastases is usually an old bronchiectasis, a pulmonary abscess, or suppuration of the pleura.

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[1] *A. Young,* An Abscess of the Brain. "St. Bartholomew's Hosp. Rep.," XL.

[2] *R. Meyer,* "Berl. klin. Wochenschr.," 1868.

According to *Oppenheim,* the pulmonary affection that places the brain in greatest jeopardy is putrid bronchitis. Besides this, gangrene of the lung, pulmonary abscess, empyema and in rare instances, tuberculosis of the lungs with cavity formation also come here under consideration. My assistant, *Walter Groth,*[1] compiled a statistic in which suppurative diseases of the bronchial lymph-glands was an etiologic factor four times. The compilations of *Claytor,*[2] *Fuchs* (older literature) and *Groth* (recent literature) show the following etiologic table:

	Claytor	*Fuchs*	*Groth*
	58 Cases	40 Cases	33 Cases
Bronchiectasis *	20	14	15
Purulent bronchitis *	9	9	
Empyema	10	3	4
Gangrene	7	7	3
Tuberculosis	5	3	....
Pulmonary abscess	3	3	5
Pneumonia	2	1	2
Gunshot wounds of the lungs	2	1	....
Disease of the bronchial lymph-glands	....	....	4

*Both of these groups belong to one.

Schorstein ("Cerebral Abscess in Diseases of the Lungs," *Lancet,* 18th of September, 1909) found it in 55% of bronchiectasis and bronchitis, in 22% of empyema, and in only 4.5% of tuberculosis of the lungs.

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[1] *Groth,* Beitrag zu den metastatischen Hirnabszessen pulmonalen Ursprungs. Inaugural Dissertation. Berlin, 1910.

[2] *Claytor,* Multiple Brain Abscess following Empyema. "Philad. Med. Journ.," 1901.

OBSERVATION XI, 5

Fistula of an Old Empyema and Bronchiectasis. Radical Operation with Resection of the Right Lower Lobe of the Lung. Extremely Numerous Metastatic Abscesses in the Whole Brain, Cerebellum and Pons. Death Nine Days After the Operation. Friable Thrombus in a Small Pulmonary Vein.

As a child, this patient, who was twenty-four years old and free from hereditary taint, had measles, diphtheria, and influenza. When fourteen years of age he went through an attack of right-sided pneumonia which, it is said, completely disappeared after an illness of five weeks. A year later, however, profuse expectoration set in which, in the sputum glass, separated into two layers. A sputum examination was made at that time, the result of which is unknown to the patient. He states that he suffered from this expectoration to a greater or less extent for a period of about three years. During that time he felt well and complained of no disturbances whatever. He was able to follow his occupation, which was that of a trapezist, without inconvenience. In 1903 his condition became worse. He was running a high temperature and, therefore, compelled to go to a hospital. At the first "simple" resection of ribs, 1½ litres of pus were evacuated. The second operation was of a severer nature and was performed a little later. He had to be dressed every day until 1907, on account of a fistula that persisted after the second operation and from which large quantities of malodorous pus were draining. Another operation was performed in 1907, at which a portion of the lower lobe of the right lung was resected. Despite all this, the fistula did not close and the persistent suppuration required constant medical attention. Discouraged with his continuous suffering, the patient decided to enter the Augusta Hospital to subject himself to a radical operation.

Upon examination the pale, moderately nourished man showed no abnormalities of the heart and abdominal organs. Neither dulness nor catarrhal symptoms were found over the left lung or the upper portion of the right. Satisfactory percussion could not be carried out on account of the absence of ribs in the right lower half of the thorax. Auscultation showed diminished respiratory murmur. There was a moderate cough with purulent expectoration which was free from tubercle bacilli. The urine was normal. Posteriorly, at the level of the 7th and 8th rib on the right side about four fingers from the median line, an opening was found which measured 4: 2½ cm. It was surrounded by rigid, cicatricial tissue. The thorax was here sunken in to an extent of about the palm of a hand. In the other part of the opening another aperture was seen which could be traced with the sound inward and upward to a distance of 3 cm. When the patient was coughing, profuse quantities of pus were discharged from this opening and the lung tissue protruded from it like a hernia, the size of a plum, in the form of a reddish mass. A real pulmonary fistula (a communication of a bronchus with the external opening) did not exist, because, when the patient kept his mouth and nose closed, no air was aspirated in the opening of the thorax. No tubercle bacilli were found in the sputum.

The patient underwent an operation on the 21st of July, 1910. The firm cicatrix surrounding the fistulous tract was dissected and I resected a number of ribs together with the much thickened pleura and the presenting portion of the lung. During this, numerous abscess cavities and tracts, which were filled with malodorous pus, were discovered. The purulent, infiltrated section of the lung had to be taken away, so that finally the entire lower lobe of the right side was resected. The large wound was now closed and loosely packed with vioform gauze, and after the insertion of a drain into the upper and lower angle, it was sutured. The patient withstood the severe operation tolerably well. His general condition, temperature, pulse, and the healing of the wound, showed no peculiarities in the first days after the operation.

On the fifth day, however, a striking change in the clinical picture took place. The patient became restless and complained of violent headaches which were mainly perceived in the back of the head. In the right arm (which had already shown a certain rigidity the day before and could only be moved with difficulty and diminished power), clonic spasms were observed a number of times. The speech of the patient was indistinct; he could not find the proper words, and when spoken to, he evidently did not understand. The increasing apathy and the rapid aggravation of his general condition did not permit a thorough examination for aphasia. On the sixth day twitchings were observed in the left lower extremity. He at once became dizzy and fell to the left or to the right side when attempting to sit up in bed. On the following day contractures were demonstrated in the left arm, the aphasia continued, the sensorium was occasionally cloudy and the patient frequently vomited. An ophthalmoscopic examination showed marked bilateral optic neuritis; the papillæ were red, somewhat swollen and cloudy, and the veins were tortuous and dilated. In the course of another day the right arm became entirely paralyzed and the spastic manifestations in the right half of the body became more pronounced. In the last few days we could not elicit the tendon and periosteal reflexes. The apathy and aphasia became worse and finally culminated in stupefaction and profound coma. The temperature rapidly mounted to 40° C., and *Cheyne-Stokes'* respiratory phenomenon set in. On the 29th of July (nine days after the operation) the patient died from progressive cardiac asthenia.

The post-mortem examination of the brain *(Professor Dr. Oestreich)* showed remarkable findings. After removing the very tense but otherwise normal dura, a number of circumscribed foci of pus were seen on both cerebral hemispheres; i.e., in the parietal and occipital lobe of both sides. There were three foci ranging in size from that of a pea to a cherry. They were projecting somewhat and covered with normal arachnoid. Similar foci were found at the base of the right frontal lobe and on the pole of the right temporal lobe. Separation of the median fissure disclosed on the left side a number of foci the size of a cherry. No changes were found in the sinus longitudinalis or in the other sinuses. They were filled with fresh, coagulated blood. The arachnoid at the base of the brain was delicate and transparent. The arteries were moderately turgid, their walls not altered and their lumina free from emboli.

Section of the cerebral substance also disclosed numerous abscesses ranging in size from that of a pea to a cherry. Almost every section showed new abscesses and a number of foci were also discovered in the region of the large ganglia and the internal capsule. There were numerous abscesses even in the cerebellum and the right side of the pons. They were nowhere surrounded by a membrane. The cerebral substance surrounding them was œdematous and moderately vascular. The number of abscesses was estimated to be at least seventy.

The very small part of the remaining lower lobe of the right lung showed cirrhotic bronchiectases with purulent contents. The middle lobe was small and permeated with numerous bronchiectases of smaller size. The upper lobe was free, vascular, and somewhat moist. Considerable breaches in any of the vessels could not be discovered. The larger branches of the pulmonary vein did not contain thrombi. In one of the smaller branches, however, a friable thrombus was found attached to the wall of the vessel. The organs of the neck and the abdominal viscera showed nothing abnormal. There were no metastatic abscesses.

The anatomic diagnosis was: Cirrhotic bronchiectases in the right lower and middle lobes of the lung. Thrombosis of a small branch of the pulmonary vein. Multiple, recent cerebral abscesses. Fatty degeneration of the myocardium.

This case is typical in many respects. As in the great majority of cerebral abscesses of pulmonary origin, the etiology was also in this case a primary focus in the form of a purulent bronchiectasis. Thrombosis of one of the branches of the pulmonary vein occurred in the region of a bronchiectatic cavern which was filled with stagnating secretions from which the pathogenic material was carried to the brain by embolism. It was also characteristic that the abscesses were located exclusively in the brain, while all other organs were free from metastases. Such a clinical picture of embolism, followed by a rapid development of multiple abscesses, has frequently been observed in instances of pulmonary suppuration. The large number of foci uniformly distributed in the brain was striking.

Soon after the appearance of the intracranial complication, the diagnosis of cerebral abscess was no longer doubted. It was only necessary to consider the general manifestations, the ophthalmoscopic findings, the focal symptoms and the original trouble. In the beginning, I seriously thought of trephining, but the symptoms plainly pointed to the multiplicity of the abscesses which created a contra-indication for operative intervention.

Operation for Metastatic Cerebral Abscess

Contrary to abscesses of otitic, rhinogenic, and traumatic origin, those developing on a metastatic basis are seldom the subject of surgical therapy. Only few of such cases treated by operation are reported in the literature. I shall cite an instance.

OBSERVATION XI, 6

Empyema Following Gunshot Wound. First Manifestations of Abscess of the Brain Three Months Later. After Six More Weeks Localization in the Left Central Region. Successful Operation. Death Two and a Half Months Later from Abscess of the Medulla Oblongata.

The patient in this case was a young man of eighteen who, on the 16th of September, 1905, sustained a gunshot wound of the left lung, which was followed by a pleura-empyema. After the ribs were resected the suppuration continued, and in the beginning of January, 1906 (three and a half months after the injury), violent vomiting, severe chills, high fever and headaches set in. These manifestations could not be accounted for by his attendants (the patient was at that time under treatment in some university clinic) and five days later they had completely disappeared. While he was apparently in perfect health, there gradually developed, on the 17th of February, 1907, a paresis of the left lower extremity, and five or six days later, the left arm became paretic. From now on the general condition of the patient became gradually worse; he became weak and apathetic and showed a tendency to somnolence. He complained of excruciating headaches.

H. Oppenheim examined the patient on the 13th of March, 1906 (six months after the injury to the lung), and the following conditions were found: There was sensitiveness to pressure and percussion on the left side of the skull corresponding to the motor area. There was also a paresis of the right facialis, a total paralysis of the right arm, partial paralysis of the right lower extremity with spastic manifestations, slight disturbances of speech (articulation), excruciating headaches and occasional vomiting. The fundus oculi was normal. There was no fever at any time. *Oppenheim* made a diagnosis of metastatic, evidently solitary abscess of the left motor area in the region of the centre of the facialis and the arm. He recommended an operation. This was carried out on the 12th of March.

After reflecting the osteoplastic flap, the dura appeared very tense, strikingly red and so thin that the vessels of the pia showed through it. Its middle portion bulged perceptibly forward. After fashioning a flap, the arachnoid appeared strikingly dry and whitish in color. In order to obviate the possibility of infection from the contents of the abscess, the space between the pia and dura was carefully packed with vioform gauze. This was followed by multiple punctures. 2 cm^3. of a puriform fluid was obtained from the middle of the field of operation. An incision about 4 cm. long was made over the area punctured, after doubly ligating two large veins of the arachnoid.

Plate XII, Fig. a, Vol. I, depicts this act of the operation. The brain was retracted with spatulæ at the point corresponding to the incision. An abscess cavity, which was located from 2 to 3 cm. under the cortex, now came to view. It was surrounded by a sort of capsule and covered with smeary, grayish-yellow pus. The cavity was drained and packed, after which the osteoplastic flap was loosely reposited.

Microscopic examination of a portion of the wall of the abscess showed numerous hemorrhages and infiltrations of the brain tissue with polymorpho-nuclear leucocytes, besides which there were also foci of degeneration. The nuclei stained indistinctly and the cells and nuclei were granular.

At the first dressing (five days after the operation) a cerebral prolapsus the size of the fist of a child was found which dislodged the drainage-tube. Gradually, in the post-operative course of the case, it became smaller, so that fourteen days after the operation it projected only 1½ cm. above the level of the skull. After taking away a number of degenerated parts of tissue, the flap was reposited and sutured to the skin with silk in front and behind. A gaping space about 1 cm. remained in the upper portion of the wound, from which the cerebral mass was protruding. Compression of the prolapsus with gauze strips and cauterization with silver nitrate rendered it still smaller, so that in the beginning of May it was covered with skin and its uppermost part corresponded with the level of the surrounding tissues. From the middle of the exposed cerebral surface clear liquor drained for a long time through an opening the size of the head of a pin.

With reference to the clinical symptoms, a striking improvement in the general condition of the patient was noticed immediately after the operation. He felt subjectively well and there were no headaches nor vomiting. The stupefaction had disappeared, the apathy gave way to mental activity and the patient was busy reading and took great interest in what was going on about him, in politics and in general news. Immediately after the operation, however, the aphasic disturbances were quite marked. During the first day the patient could only say "Yes," "No." Soon, however, his speech improved so that after a fortnight he was able to read without difficulty, and after a few more days he spoke fluently and constructed sentences. Only his articulation was slightly disturbed. His understanding of words was only slightly affected.

Of the paralyses, the facialis showed a decided improvement, so that three days after the operation the patient was able to close his eye, and the lower branch was also less paretic. The spastic paresis of the right arm also showed improvement, so that finally adduction and inward rotation of the arm as well as slight flexion and extension of the elbow-joint were executed. All sensory qualities of the hand were disturbed. In the right lower extremity a slight reduction in the sensibility and spastic symptoms remained. The mobility of this limb improved to such an extent that, besides total active motility in the knee and hip joints, active movements could be performed with the joints of the foot and toes but with reduced power.

The improvement in the general condition of the patient continued until about the middle of April. On the 10th of April, however, he became rapidly worse. The aggravation of his condition was attributed to the possibility of hemorrhage, because, in a certain part of the dressings corresponding to the prolapsed brain, fresh blood was seen. The patient was vomiting and complained of severe headaches and a spastic paralysis was noted in the right lower extremity. At the end of April he could not execute active movements at all with that limb. The motility of the right arm was completely gone with the exception of inward rotation. The left lower limb also showed spastic manifestations (ankle-clonus, *Babinski,* exaggerated patellar reflex). To this, motor disturbances of irritation were added so that on the 15th of April, clonic-tonic spasms set in, which began in the lower extremities and remained here strongest. Both arms were also twitching, and the head, the bulbs, and the left angle of the mouth were drawn to the left. This attack lasted ten minutes and was accompanied by loss of consciousness, after which the right angle of the mouth was seen twitching. Outside of the motor disturbances of irritation mentioned, symptoms pointing to a bulbar disease were noted about the middle of May. The patient could no longer articulate, he frequently swallowed the wrong way and gradually became weaker. He died on the 19th of May (about two and a half months after the operation), with all symptoms of respiratory paralysis.

There is a great probability that another abscess had developed in the medulla oblongata. It is also possible that this focus developed simultaneously with the first; this may have been responsible for the disturbances of articulation. No autopsy.

This observation is in many respects the counter-picture of Observation XI, 5. In the latter, the course was acute, lasting a few days, while in the former, it extended over a period of months. The initial stage was characterized by febrile disturbances that continued for a number of days and were accompanied by headaches, vomiting, and chills. This was followed by a longer period of complete latency, during which the patient was apparently well, and finally the disease manifested itself by focal symptoms and distinct signs of cerebral compression.

Despite the fact that the second abscess appeared only later, operative intervention was decidedly justified. At the time of the operation all symptoms distinctly pointed to a localization of the focus. The second abscess evidently remained latent.

The operation had, therefore, been performed despite the experience that metastatic abscesses frequently occur multiple. Surgical intervention is the only way that may lead to a cure of the patient, because spontaneous cure of a cerebral abscess by calcification and resorption of its contents, or evacuation to some part on the surface has not as yet been conclusively proven to ever take place.

It is a positive fact that emboli following suppurative processes in the lungs, attack the brain by preference. This fact is still more remarkable when we think that endocarditic emboli, the result of endocarditis, affect other organs much more frequently than the brain. The kidney and spleen are first to be affected in this instance. In seventy-six cases of emboli from the left heart, which *Sperling* reported in his Inaugural Dissertation in the Report of the various Sections of Virchow's Institute, in 1872, the kidneys were affected 57 times, the spleen 39 times, and the brain only 15 times. Such emboli are therefore third in frequency. *Groth* endeavors to explain this fact on the mechanical conditions of the circulation. He states that it makes a great difference whence the thrombus is dislodged; i.e., whether it arrives in the left heart from the lungs, or whether it is torn away from the endocardium itself.

Professor Oestreich offers the following explanation: Before a foreign body floating in the aorta reaches the cerebral arteries, it naturally arrives first at the point of origin of the large vessels of the neck. Such a body would therefore leave the left ventricle in such a manner as to soon reach the direction of the blood-current just alluded to. Those elements, on the other hand, that come from the mitral or the aortic valves and lead to embolism, course in the axis of the blood-stream of the aorta and therefore occasion, as stated, more frequently embolism of the spleen and kidney than of the brain.

Detached particles coming from the pulmonary veins at first meet in the left auricle a current, the direction of which does not lead straight to the mitral opening. It is therefore possible that they are thrust against the auricular wall, whence they travel in the border of the stream along the left border of the left ventricle and the septum; i.e., on the convex wall of the aorta. This may explain why emboli originating in the lungs are so frequent in the brain.

The finer the division of the material coming from a septic thrombus into the blood of the carotids, the greater the number of metastatic abscesses and the more uniform their distribution in the brain. The result will then be as in our first case (Observation XI, 5, p. 916). If the emboli are larger, they attack, preferably, the distribution of the arteria fossæ *Sylvii* (especially the left). In this category belong the abscess operated upon in our second Observation (XI, 6, p. 920).

Solitary Metastatic Abscesses

In looking through the literature on the etiology of metastatic suppurations of the brain, I find three cases described in which a correct clinical diagnosis was made of the location of the abscess in which an operation was not undertaken for the reason that metastatic abscesses of the brain are believed to be invariably multiple. In all of these cases the post-mortem examination showed a solitary abscess which could undoubtedly have been benefited by an operation. *Bibrowicz*[1] reproaches himself for not having operated, and emphasizes the fact that it is chagrining to the surgeon to find at the post-mortem examination an uncomplicated, easily accessible focus of pus. The statement that the great majority of cases of metastatic suppurations of the brain are multiple cannot be verified by actual clinical experiences. Forty-five per cent. of the cases of abscess reported in the literature of the last twenty years were solitary.

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[1] Beiträge zur Klinik und Chirurgie des Hirnabszesses. *Bruns'* Beiträge zur klinischen Chirurgie, Bd. XLVII.

Injuries of the Brain

Cerebral Concussion, Cerebral Contusion, Cerebral Compression

All injuries of the skull, occurring in connection with or without an external wound or complicated by fractures of the skull, may give rise to cerebral concussion, cerebral contusion and cerebral compression. All of these three conditions may frequently appear together to a more or less marked degree.

By

Concussion of the Brain (Commotio Cerebri)

we understand all those disturbances of function that occur immediately after an injury and which may last from a few minutes to many hours. The symptoms are principally those of the general cerebral manifestations which we find in many other conditions: headaches, rigidity of the back of the neck, vomiting, psychic excitation, pallidity of the face, disturbances of consciousness which may be of various degrees (even profound coma), and affections of the pulse and respiration, either retardation or acceleration. Paralyses and manifestations of irritation may interchange. Complete cure may be expected in mild cases. If such be the case the disturbances of circulation, to which the manifestations are mainly due, soon adjust themselves. In severe cases there is no such recuperation, and the concussion may in a short time lead to the death of the patient.

When we study the symptoms individually, we find that concussion of the brain, if more than of moderate degree, leads to immediate loss of consciousness, snoring respiration and complete loss of reaction even in the most sensitive parts of the body (cornea). The pupils are widely dilated and do not react to light. The patient vomits and has involuntary actions of the bladder and rectum. The pulse may be extremely variable. It may be highly accelerated, fluttering and irregular, or it may be slow and full. In some instances the slightest movements of the patient will influence the rhythm in the extreme. This condition may set in immediately after the injury and the patient may remain unconscious for a number of days or he may soon become mentally clear again, and the suspended functions are then reestablished. In such instances the patient complains of violent headaches. It is characteristic of these cases that the individual does not recall anything relating to the injury. There may also be amnesia with reference to occurrences immediately preceding the accident.

In the severest cases the patient does not awaken, and death supervenes under manifestations of respiratory or cardiac paralysis. Improvement of all manifestations does not always run the same course. A word of caution is here necessary. In cases that have progressed satisfactorily there will at times suddenly set in threatening symptoms without the existence of an actual morbid focus within the skull. This fact should be taken cognizance of, for irreparable damage may be done by surgical intervention at such times and under these circumstances.

In the case of a woman, forty-eight years of age, who sustained a severe fall on the left side of her head the severe manifestations of cerebral concussion had regressed within a day. A pure biliary vomitus was ejected exactly twenty-four hours after the casualty. She regained at the same time consciousness which was interrupted by relapses. Her pulse, which at first was 56 beats per minute, had regained its normal frequency of from 80 to 84, and the headaches were no longer severe. Forty-two hours after the accident, the pulse fell to 58 beats per minute and it had the characteristics of increased cerebral pressure (hard, full, slight irregularity). This was accompanied by violent frontal headaches and pains in the back of the neck, but there was no vomiting, and the taking of nourishment as well as the functions of the bladder and rectum were normal. These threatening manifestations continued for about three days. On the fourth day they began to recede and the headaches disappeared. On the following day the pulse mounted to 70 beats per minute, its tension and hardness regressed, and the patient felt comparatively well. Vertigo upon lifting the head, which was occasionally accompanied by nausea, disappeared after six more days, after which the pulse became normal again. Outside of slight lachrymation from the left eye, the patient remained entirely free from disturbances for many years.

I have repeatedly observed similar manifestations. I sought their explanation in the following observation. Every contusion, no matter in what portion of the body, is followed soon after the injury (usually two or more days) by processes of reaction; viz., œdematous swelling, infiltration of the tissues with round-cells accompanying the extravasations of blood, and increased pain. In distortions of the joints the inflammatory (traumatic) œdema (œdema calidum) is a constant manifestation. These processes are in all probability present in cases of cerebral concussion. In contradistinction to cerebral contusion we do not find microscopic changes in cases of concussion, and the general appearance of the brain substance and its nutrition remain undisturbed. We must remember, however, that the nature of these changes is speculative and that traumatic changes in the cerebral substance, while not accessible to observation, must nevertheless exist. The reaction of the brain to traumatization in these cases would in all probability be essentially the same as those of coarse contusion; i.e., sugullation, œdema, and round-cell infiltration.

If now, as is usually the case in cerebral concussion, large portions of the brain are affected, the occurrence of even slight œdema would necessarily be followed by an increase of the cerebral volume within the rigid skull to such an extent that slight manifestations of cerebral compression would ensue. The morbid manifestations will then disappear in a few days in correspondence with the degree of resorption of the pathologic transudate or exudate. The last circumstance proves conclusively that the symptoms in a given case were not occasioned by a large extravasation of blood or a morbid focus confined within the skull. However, in some cases the symptoms will warrant the latter assumption if a few days after the accident (at a time when the manifestations of cerebral concussion are usually receding) such symptoms as paresis of one facialis, differences in the pupils, loss of reaction of one pupil, diplopia as a result of disturbance of the ocular movements, are observed to occur. Under such circumstances we will think of contusion of certain sections of the brain, extravasations of blood and involvement of the nerves at the base of the brain. Nevertheless even these manifestations do not call for surgical intervention so long as they show tendencies to regression. With these statements we have already encroached upon the chapter on *Cerebral Contusion,* the manifestations of which are in many respects similar to those of cerebral concussion. In the nervous elements are damaged by applied force. The damage thus created may escape the eye of the observer and yet may be severe enough to cause the death of the patient. In other instances again extensive distortion of the cerebral mass is discovered at the post-mortem table. There are many grades between these two extremes. In cerebral contusion also, the symptoms occur immediately after the infliction of the injury, but in contradistinction to concussion they last longer. This, of course, is easily explained on an anatomic basis. Furthermore, focal manifestations are characteristic of cerebral contusion. This is of greatest diagnostic value when the cortical region of the central area is involved, because, as seen above, every contusion or disturbance of the nervous elements in this region will give rise to characteristic symptoms. The clinical manifestations resulting from traumatizations of the respective cerebral areas are those found in neoplasmata of the various regions spoken of above.

Cerebral Contusion (Contusio Cerebri)

Rises of temperature in connection with injuries of the brain are also of value if inflammatory processes can be excluded from the etiology of the case. Transient elevation of temperature is observed in cases of concussion, moderate hyperthermia is seen in cases of hematoma, but continued and steadily rising fever points to cerebral contusion. So-called brain-fever, which should more properly be called hyperthermia, has been spoken of in another chapter. It depends upon a disturbance of the regulation of heat akin to thermic disturbances found in paralyses.

Cerebral Compression (Compressio Cerebri)

results from injuries that cause tearing of a large vessel either within or outside of the dura mater, thereby occasioning an extravasation of its contents into the interior of the skull. The symptoms produced in this class of cases will be spoken of in the chapter on *"Treatment of Intracranial Hemorrhages."*

Treatment of Cerebral Concussion and Cerebral Compression

The first principle in the treatment of concussion of the brain is absolute rest. Even after the severe manifestations have vanished the patient must abstain for a long time from all forms of mental and physical exertion. For we frequently find that there remains in these cases a slight irritability of the meninges and of the cortex cerebri, so that every exertion provokes immediate headache, and the pulse is influenced in its quality and rhythm. Exaggerated reflexes are also an objective sign of such states of irritability. The brain will best recuperate when permitted to enjoy complete repose. In the treatment of cerebral contusion, outside of taking care of threatening symptoms, the best course to pursue is one of expectancy. Leaving the patient alone, especially children, will save many a life which, if subjected to prompt surgical intervention, will be placed in great jeopardy. I recall the case of a baby, eleven months old, who fell out of a baby-carriage rolling down the stairs. The child sustained a severe injury to the head and was brought to me in a totally stupefied, reactionless condition, with extremely unequal pupils, snoring respiration, and irregular, slow pulse (60 to 70 beats per minute). There existed a slight motor agitation in which the right extremities participated to some extent and the right facialis was paretic. There was repeated vomiting. No evidences of external violence could be discovered. On the following day the pulse was arhythmic and quickly mounted to 136 beats per minute. On the fourth day it went up to 144 and the temperature, which was normal until that time, rose to 38.8° C., and on the following evening to 39.2° C., after which it gradually fell to normal. The pulse sank simultaneously to 116 beats per minute, then to 100, and it finally became regular. Twenty-four hours after the injury the little patient became conscious again, but the right arm was completely paralyzed and the right facialis and the right lower extremity were paretic. In the following two days frequent *Jacksonian* spasms were noted in the right half of the body, occasionally assuming a general character. These convulsions ceased after the fifth day, the child became livelier and it recognized its mother. For two more days twitchings of the right angle of the mouth and of the lower jaw were observed, but these also finally ceased. The patient now gradually recovered. Three weeks later it executed isolated movements with its right arm, but these were much reduced in power and the hand was spasmodically closed. When she was sitting, the little patient soon became pale and, after a brief period, fell to the right side. Six weeks after the injury all manifestations had vanished.

In this instance we were dealing with a cerebral contusion which was responsible for the local manifestations of irritation of the motor region. It teaches that expectancy is proper treatment. We must not forget that even in cases of *Jacksonian* epilepsy an expectant course is justifiable, and will not infrequently yield satisfactory results. A good example is offered in Observation I, 19, Vol. II, p. 480. A review of the chapter on *"Traumatic Epilepsy"* is also recommended in this connection.

Severe and continued paretic manifestations indicate the exposure of the corresponding cerebral section. So much has been said with reference to technic, etc., that I need mention this fact only. Injuries in connection with external wounds and intracranial hemorrhages require separate consideration.

Treatment of Wounds of the Brain

In treating injuries of the skull it makes quite a difference whether they are complicated by an external wound or not. In instances where the skin is intact, the best course to pursue is to wait, that is, when increasing symptoms of cerebral compression do not force us to interfere. Blunt force may, especially in young individuals whose crania are elastic, cause a contusion of the cerebral cortex without fracturing the skull. Cerebral contusions will also result in cases where, for instance, the patient is thrown from a horse, etc., without necessarily fracturing the base of the skull. This may be accompanied by exudations, meningitis serosa and similar processes, the discussion of which I need not enter on in this chapter. It should be mentioned, however, that I have frequently observed such injuries to be followed by a decrease in the pulse-rate to 40 beats per minute (patient in dorsal decubitus), disturbances of certain cerebral nerves (facialis, movements of the eyes), headaches and asthenic conditions which would continue many months after the injury. The brittle lamina vitrea fractures by far more easily than the diploë and the external table. Tearing of the lamina vitrea and spiculæ of bone may injure the membranes of the brain or the cerebral substance itself. X-ray examinations, especially stereoscopic pictures in their present day of perfection, will usually lead to a correct recognition of the existing injury to the bone.

In cases where the skin is injured, I consider it good practice (in times of peace) to cleanse and disinfect the wound and apply over it an aseptic dressing and to await further developments. There is no doubt that such treatment has in the majority of instances been followed by satisfactory results. However, without a thorough examination of the wound we are never able to tell whether there exists a fracture of the bone or not. We are also in the dark as to whether the dura has been torn, and what is most important, whether or not foreign bodies have penetrated into the depth which may invite infection of the wound. A young man of twenty-one was admitted to the hospital, suffering from what appeared to be a slight scalp wound which was treated in the above manner. Four days after the injury, symptoms of typical meningitis developed, to which the patient succumbed a few days later. Underneath the agglutinated wound, a fissure of the parietal bone was found, the lamina vitrea was splintered and the dura was extensively torn. The contused cortical tissue contained a few hairs. Cortical symptoms were not present. This is not surprising when we consider that the injury was inflicted in the region of the right parietal lobe—a silent territory. Failure in one case outweighs ever so many hundreds of successful cases when we consider how easily this patient could have been saved by a slight interference immediately after the injury. Therefore, any case in which there is the slightest suspicion that the wound of the scalp has become infected, should under all circumstances, be laid widely bare. We should also not shrink from trephining. With the exception of simple gunshot wounds, I am against expectant treatment of cerebral injuries.

To be more specific, I am not limiting myself even in external wounds of small size to a simple aseptic or antiseptic dressing, but proceed in a manner as if dealing with a compound fracture of the leg; i.e., I enlarge the wound of the skin and expose all pockets and recesses, cleanse them of foreign bodies (hairs, sand, etc.), remove blood coagula, cut away contused and mashed tissues, extract splinters of bone and wipe away, if need be, destroyed masses of cerebral tissue or ablate them. It is occasionally also necessary to enlarge the wound of the dura and thereby obviate the possibility of retention and decomposition of wound secretion. After the hemorrhage has been carefully arrested, the wound thoroughly cleansed and dried with sterile gauze, it is sufficiently retracted to permit thorough inspection, after which it is tamponed with sterilized iodoform or vioform gauze. This kind of treatment will cause even badly infected wounds to clear up. It is best to use the gauze tampons in the form of wicks. This permits to reposit the flap over the wound and sufficient space may be left for the emergence of the gauze to suit the individual case. Partial suture of the wound prevents to a certain measure the occurrence of the much-dreaded cerebral prolapsus which will be more likely to occur the greater the tearing of the pia. It is frequently necessary, however, to later on cover the prolapsed brain by a plastic operation and to utilize the upper layers of the bone to accomplish the desired result.

Of course, so unfortunate an outcome as in the case just related is only seldom observed. Even severe injuries of the brain with much bruising and external wound may run a perfectly aseptic course. Completely detached spiculæ of bone may heal in the cerebral substance. This, of course, happens in the absence of septic infection. Such cases may lead, after years, to the formation of fistula. As stated in the chapter on "*Traumatic Epilepsy,*" disturbances in the central region as a result of injury may occasionally be very slight, and *Jacksonian* spasms do not always occur.

OBSERVATION XII, 1

Splinter of Bone in the Centre of the Foot. Fistula Formation. Removal of Splinter. Cure.

In February, 1899, an iron bar fell on the head of a girl sixteen years of age from a considerable height. She lost her senses and after regaining consciousness, a right-sided hemiplegia was found without participation of the right facialis. A complicated depressed fracture affected the upper and middle portion of the left central region. Trephining was done in a certain hospital and the patient recovered. The mobility of the right arm gradually returned and the lower extremity also gained in strength and its movements were free.

On the 5th of March, 1902 (three years after the accident), the patient was admitted to the Augusta Hospital. She complained of paralysis of the right leg, severe general headaches and pain in the scar. An oblong scar, about 7 cm. in length, was found between both parietal bones in the direction of the sagittal suture and a funnel-shaped defect, about 3 cm. in width, was present, in the centre of which a fistula was visible. The examination of the nervous system showed the following conditions: With the exception of the right ankle-joint all joints were freely movable. The ankle and joints of the toes could not be moved actively in any direction. Passively, the right foot could be moved plantarward; dorsal flexion was possible only after overcoming considerable resistance. With the patient quiet in bed the right foot was in slight plantar flexion and the toes dorsally flexed at the metatarso-phalangeal joints. The patellar reflex was very lively on the right side and on the left it was normal. The Achilles tendon reflex was somewhat more exaggerated on the right than on the left side. Besides this, the *Babinski* phenomenon and ankle-clonus were also present on the right side. The sensibility for slight contacts with the point of the needle was everywhere retained. The right leg was considerably cooler than the left.

On the 12th of March, 1902, I excised the scar and laid bare the area of the old fracture. It corresponded to the centre of the foot. A fistula was found that permitted the passage of a medium sized probe to a depth of 3/4 cm. (measured from the dura). At this point an obstruction was met with that imparted the impression of a piece of necrotic bone. The entire indurated area was excised down to the normal brain substance. It was about the size of a cherry and a sequestrum the size of a lentil was found imbedded in granulation tissue about its centre. A cavity as large as a walnut remained behind in the brain. This was packed with iodoform gauze. The defect in the bone was covered with a *König* flap.

The result of the operation was satisfactory. Only few nervous disturbances remained behind and these were mainly limited to the big toe of the right foot. On the 24th of April, 1902, the coarse motor power of both lower extremities was considerable. The right big toe, however, was still in strong hyperextension. Its spontaneous movement was impossible. The contracture, however, could be moved passively to a considerable extent. With reference to the sensibility in the toe and its vicinity, the patient felt contacts and located them in a normal manner. She perceived differences of temperature, pain and pricks with a pin; she also recognized the warmth of the hand. She was entirely unconscious of movements of the peripheral joint of the big toe, when the central one was fixed. She perceived electrical irritation of the extensor hallucis longus to a certain degree. The function of the centre of the foot was practically restored with the exception of a disturbance in the sense of position which was limited to the big toe. The sensibility returned completely. After the operation all morbid manifestations completely disappeared.

Where threatening cerebral symptoms develop or in cases where splinters of bone driven into the brain cause manifestations of irritation and paralyses, we have sufficient reason for operative intervention, as seen from the following observation.

OBSERVATION XII, 2

Open Injury of the Right Central Region with Left-Sided Paralysis. Removal of Four Splinters of Bone from the Torn Brain. Cure, with Almost Complete Restoration of Function.

A man, twenty-one years of age, was injured on the 30th of October, 1908, while working in the field, by a prong of a hay cutter, which created a scalp wound about 1 cm. in length about the middle portion of the right side of the head. He did not lose consciousness, but vomited profusely. He fell to the ground and could not stand up. He was admitted to the hospital on the 9th of November and he complained of violent headaches which were located in the depth of the non-sutured and partly united wound of the scalp, which lay 5 cm. to the side of the median line and 3 cm. in front of the central fissure (*Krönlein* construction). The temperature was 37.8° C., and the pulse 70. There was a spastic paralysis of the left extremities.

The spasticity was quite marked in the pectoralis major, the elevators of the shoulder, the latissimus dorsi, and in the flexors of the elbow-joint; they were slighter in the pectoralis minor, in the pronators of the forearm and in the flexors of the 2d to the 5th fingers.

Outside of slight extension of the thumb and index finger and a little flexion of the thumb, index and middle fingers, all active movements were extinguished. After two or three movements, the power to act ceased even in these muscles. All periosteal and tendon reflexes of the left arm were exaggerated. The left lower extremity was entirely immobile and showed marked rigidity in the hip, knee, and ankle joints. Patellar reflex and ankle-clonus of moderate degree. *Oppenheim's, Babinski's* and *Bechterew-Mendel's* signs were absent.

Tests of the sensorium and the ophthalmoscopic examination were negative. The sensorium was free. When the head of the patient was moved passively, no restriction was discovered and he did not complain of any pain.

X-ray examination showed, about the middle of the right parietal bone, a defect measuring about 1½ cm., under which four shadows were seen which were taken to be splinters of bone.

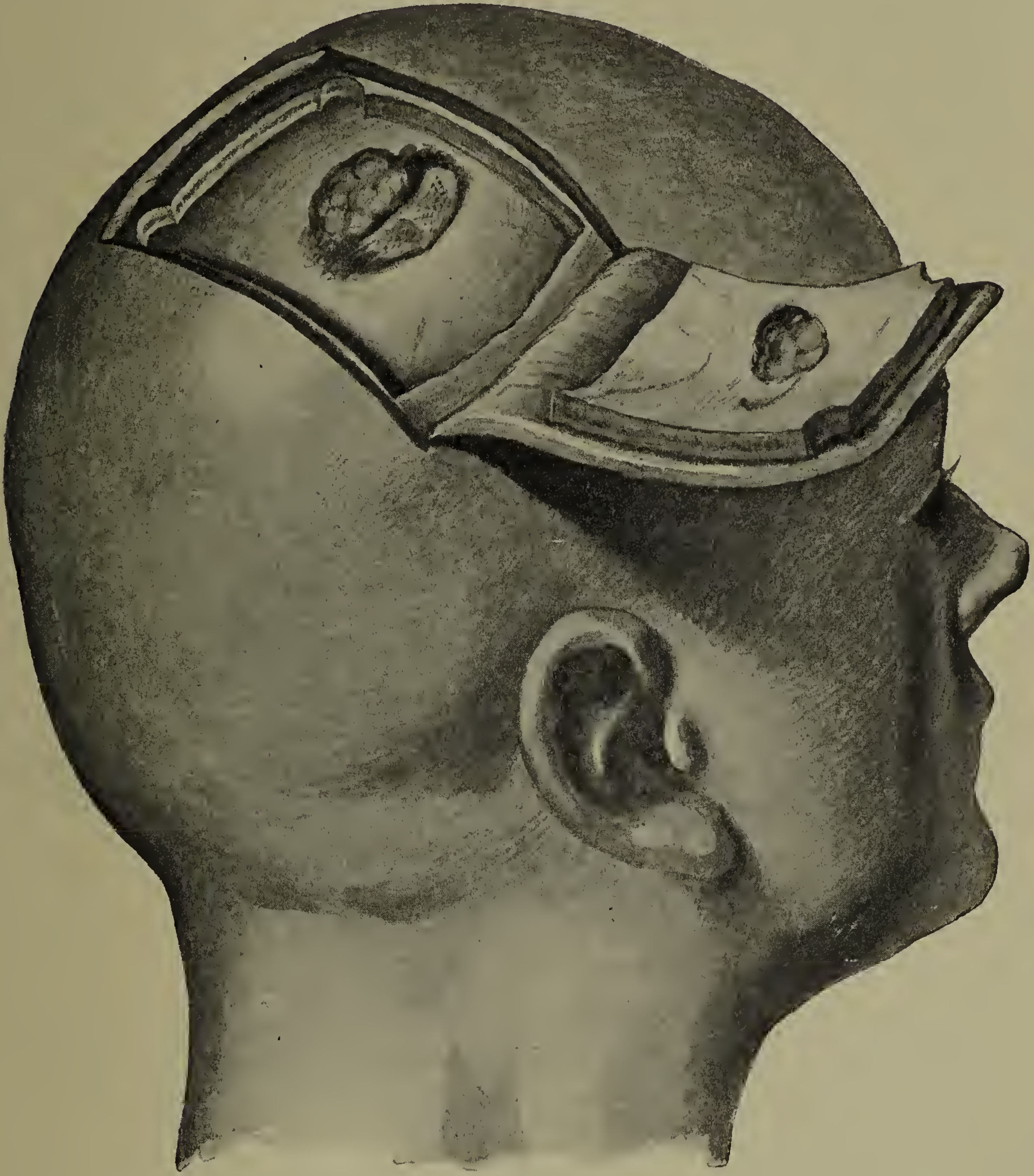

Fig. 150

On the 10th of November the right central region was trephined. After reflecting the osteoplastic flap the dura presented. It was tense, non-pulsating, and in parts ragged. A funnel-shaped opening was found about the middle of the tabula vitrea which was filled with degenerated cerebral tissue of a grayish-red color. This was directly traceable from within outward to the cicatrized wound of the scalp. Corresponding to the opening, an elevation of cerebral substance, measuring about 3 cm. in diameter, was found on the injured dura from which three superficially situated splinters of bone about the size of a pea were removed. Since, however, the X-ray plate showed a fourth shadow, I carefully probed the contused cerebral mass, and at a depth of about 1 cm. I met with resistance. This proved to be the last splinter, which was carefully extracted with a pair of dissecting forceps.

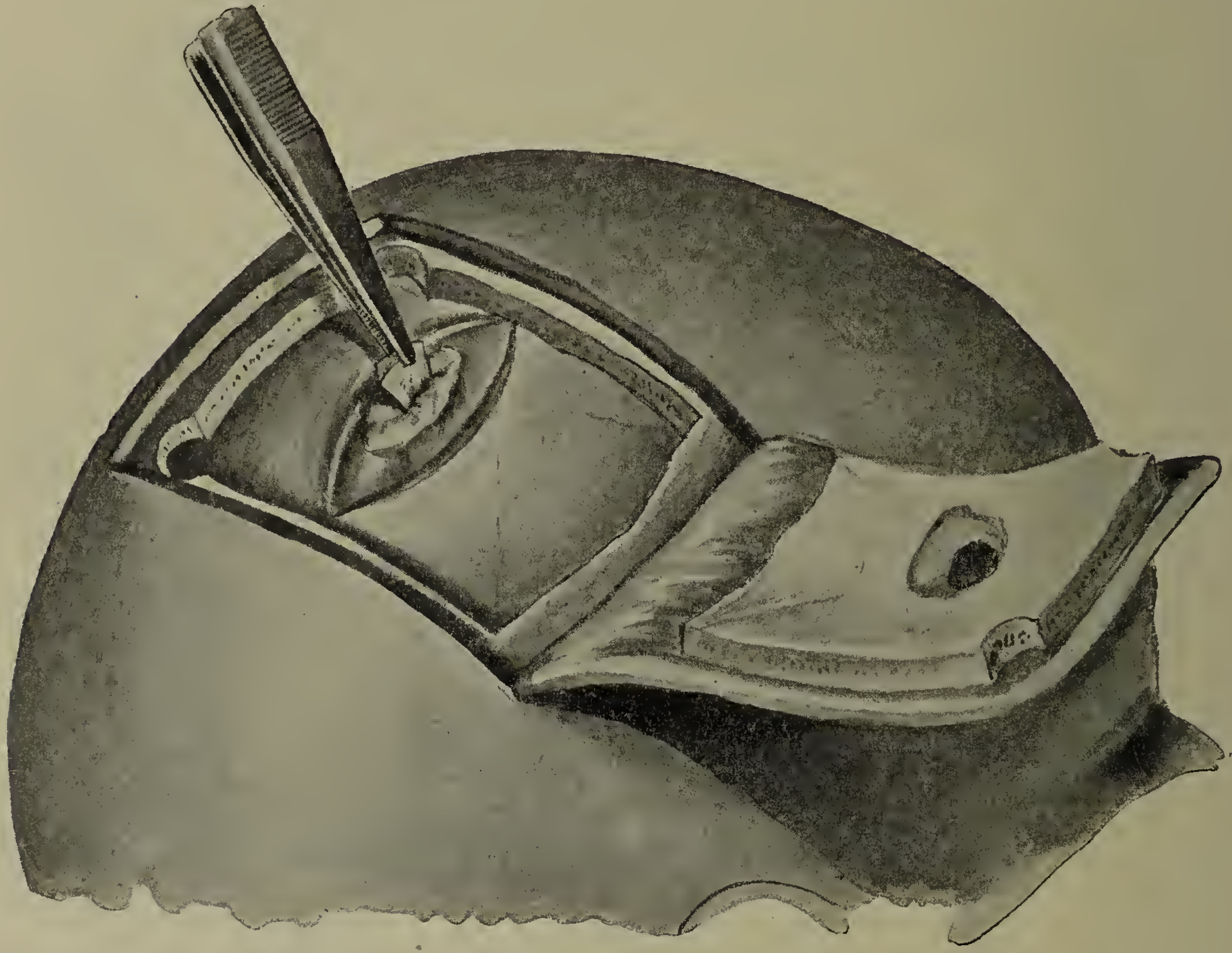

Fig. 151

The wound was loosely tamponed with iodoform gauze which was carefully packed all the way around between the dura and the brain. This was done on account of the soiled appearance of the brain. The cicatrized scalp wound was reopened and a drain introduced through it and made to rest on the tampon.

Besides this, another drain was introduced in the upper anterior angle of the flap where the iodoform tampon was emerging. The final step of the operation was now performed, which consisted of closing the wound in the usual manner by exact suturing of the osteoplastic flap. The tampons and drains were removed nine days later. Healing was perfect, and no liquor was discharging.

Immediately after the operation the active mobility of the thumb and index finger was entirely extinguished. The findings were otherwise the same as before. On the following day a fairly extensive ability to functionate was noted in all fingers, but these soon ceased after executing the movements about six or seven times. The patient was able to almost completely close his fist. On the lower extremity, however, no change could as yet be observed.

On the 12th of November the patient was able to actively move the fingers of the left hand for more than twenty times without much fatigue. The spastic resistance in the shoulder and elbow joints had considerably decreased. On the following morning the patient was able to bring his left hand to his nose. Active movements could satisfactorily be performed in all joints of the left arm. The motor power of the left hand had considerably increased. The spasticities in the upper extremity were gone. In the following days the mobility and power of the arm had still more improved, but the lower extremity showed no changes in this respect, with the exception that the spasticities were almost gone. No pathologic findings could be demonstrated in the facialis and in the area of the trigeminus. There were no sensory disturbances in the left extremities.

On the 27th of November, about seventeen days after the operation, the patient was able for the first time to slightly abduct, adduct, flex and extend his left lower extremity in the hip-joint. This improvement was more marked in the course of the following days, and it soon extended to the knee-joint so that the patient was able on the 4th of December (after three and a half weeks) to get up and walk when supported. Active mobility in the left ankle-joint was gradually reestablished, but in the joints of the toes it had not as yet returned on the day the patient was discharged from the hospital (January 10, 1909). The after-treatment consisted of walking exercises, massage, and electricity.

An examination of the patient made in March, 1909, showed normal conditions throughout, with the exception that there was an absence of active movements in the toes and a slight restriction of mobility in the knee-joint.

Probing of wounds of the brain, as practised in this case, I consider permissible only in the operating-room where everything is in readiness for any emergency that may arise. It requires great dexterity to discover a splinter of bone or a similar body in the pulpy cerebral mass by the use of the probe without creating false passages and thereby inviting new infection. The use of the sound in such cases should therefore be very restricted. Where X-ray examinations can be made, the probe is usually unnecessary.

Bullet and Stab Wounds

In bullet and stab wounds of the brain we usually limit our treatment to dressing of the wound. We step to operation only in those cases where we have to deal with hemorrhages either from a sinus or from a large vein leading from the pia mater to one of the sinuses or perhaps from the middle meningeal artery or one of its branches and finally from the carotids. Such extravasations of blood may lead to manifestations of cerebral compression or occasion focal symptoms. Experience teaches that gunshot wounds of the brain, as a rule, do not carry with them special dangers of infection, because the bullet, as can be readily conceived, is sterile. Infection follows only when septic particles are carried with it into the depths. If the external wound be clean-cut and not infected, all that is necessary is to apply a protective dressing. Bullets may heal in the brain without giving rise to any disturbances, provided, of course, that they are not located in important centres. It is also possible for bullets that have remained quiescent for a certain period to later on give rise to severe manifestations which force one to an operation.

A remarkable manifestation is offered by

Wandering of Bullets in the Brain

This is caused by the weight of the missile and the softness of the surrounding cerebral substance. Wandering may proceed without any symptoms. This is the case when the regions involved are of minor significance or where the trouble proceeds through the tract of injured brain tissue created by the shot. In such cases repeated X-ray examinations will aid us greatly to follow the bullet.

OBSERVATION XII, 3

Revolver Bullet in the Right Upper Parietal Lobe. Bullet Returned to the Region of its Point of Entrance in the Neighborhood of the Frontal Eminence.

On the evening of the 2d of September, 1909, a young man of nineteen was shot over the right eye with a revolver of 6 mm. calibre. The point of entrance was close below the frontal eminence. *Dr. Dandelski,* of Posen, informs me that the patient retained full consciousness and during the same night vomited repeatedly. The left half of his body, including the entire region of the facialis, was at once paralyzed, and in the first ten days after the accident there was diplopia. An X-ray examination, made on the 8th of September, in Posen (see Fig. 152, p. 942), showed that the bullet was located in the posterior upper portion of the skull in the region of the upper parietal lobe, while its point of entrance was below the tuber frontale and was marked by a small, narrow slit. The track of the gunshot wound, therefore, ran sagittally and somewhat posteriorly and upward through the right hemisphere. No spasms. After the shock was over, the paralyses gradually regressed in the following order of succession: At first facialis, then fingers, forearm and arm, then thigh and finally leg and foot. The wound healed without reaction. The patient left his bed in the eleventh week after which he was rolled about in a wheel chair for two or three weeks. After that he was able to walk on crutches and finally he dispensed with these. Since the beginning of January, 1910, the patient walked about without any support.

Another X-ray examination, made also in Posen on Dec. 20, 1909, showed the same conditions as found on Jan. 28, 1910, in the picture made for me by *Dr. Immelmann,* of Berlin. (See Figs. 153, 154.) The patient was sent to me at that time and only the following morbid manifestations were demonstrable: There existed a slight flexion-contracture of the left knee which caused a somewhat spastic gait; the peroneal group was slightly paretic. Reaction of degeneration was nowhere demonstrable. On the inner border of the left foot and in the big toe, contacts with the brush and pricks from a needle were occasionally interchanged. The sensation was otherwise intact. *Babinski's* phenomenon was present on the left side. The ophthalmoscopic examination was negative. These findings therefore contraindicated a removal of the bullet. I advised expectancy under the supervision of a physician.

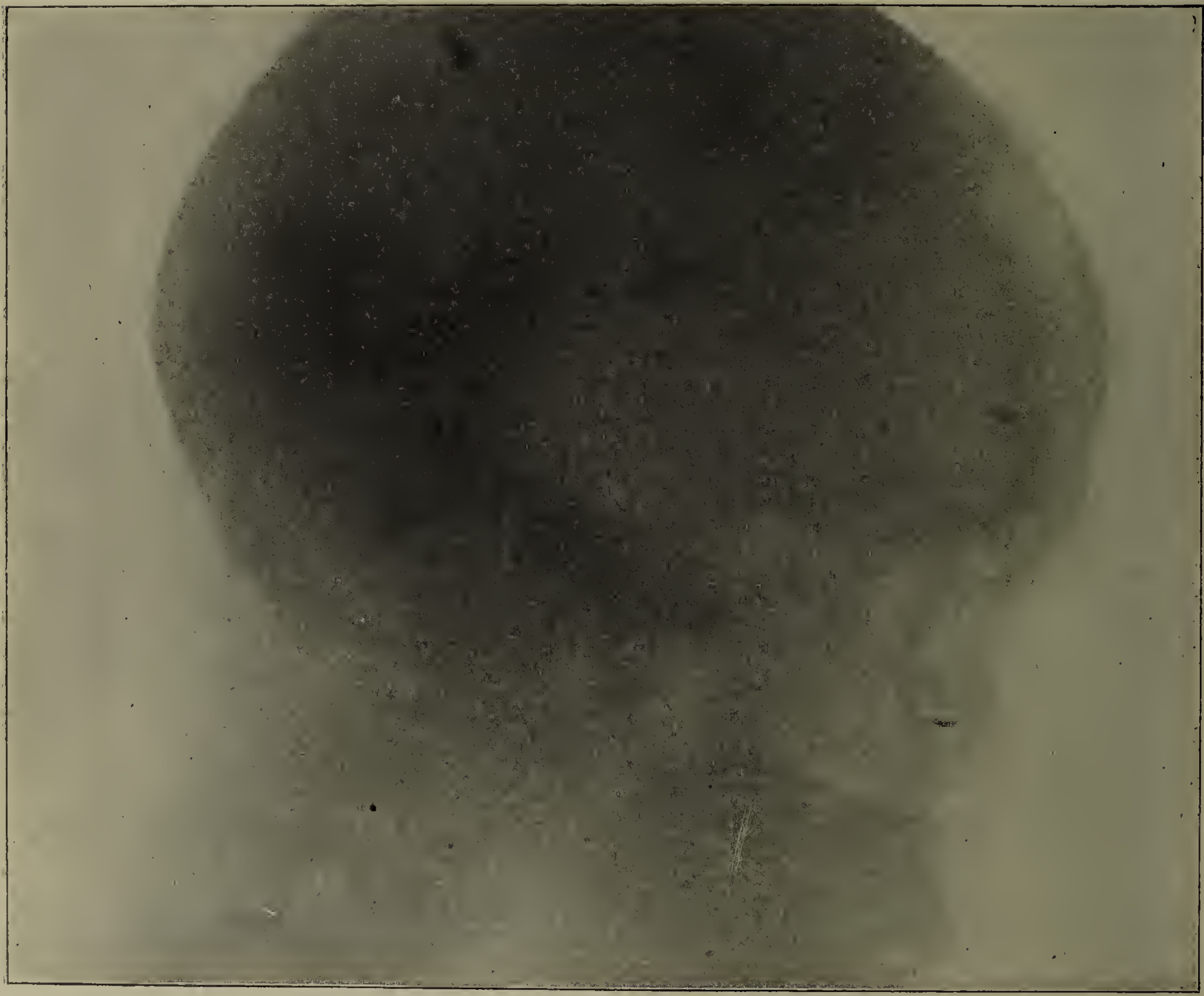

Fig. 152

The Roentgengrams show that from the time the patient had left the bed (from the middle of November to the 20th of

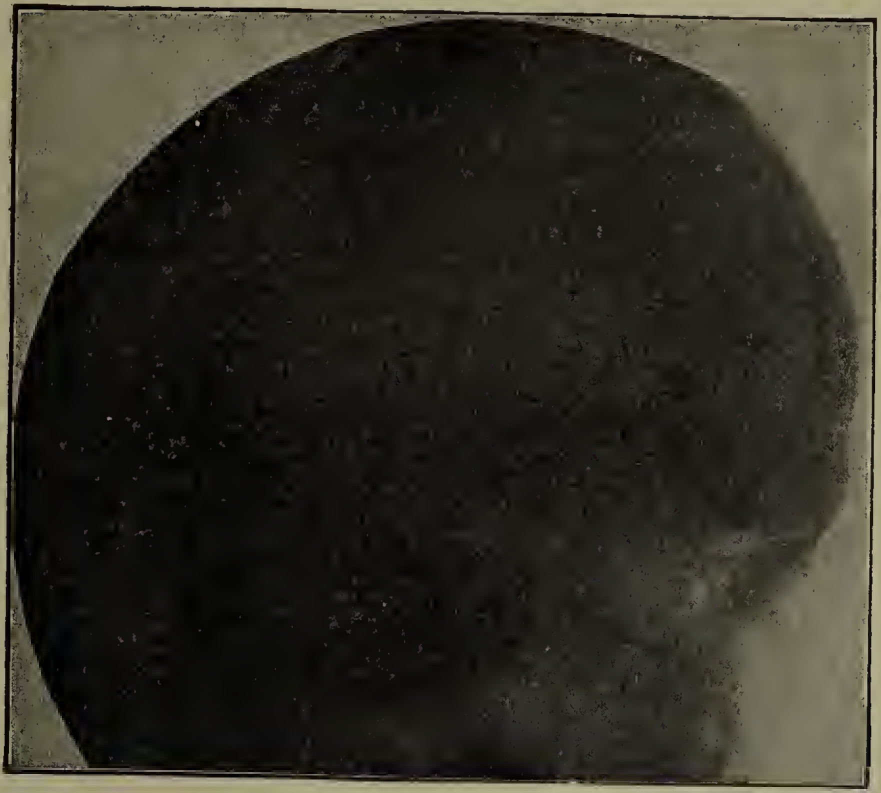

Fig. 153

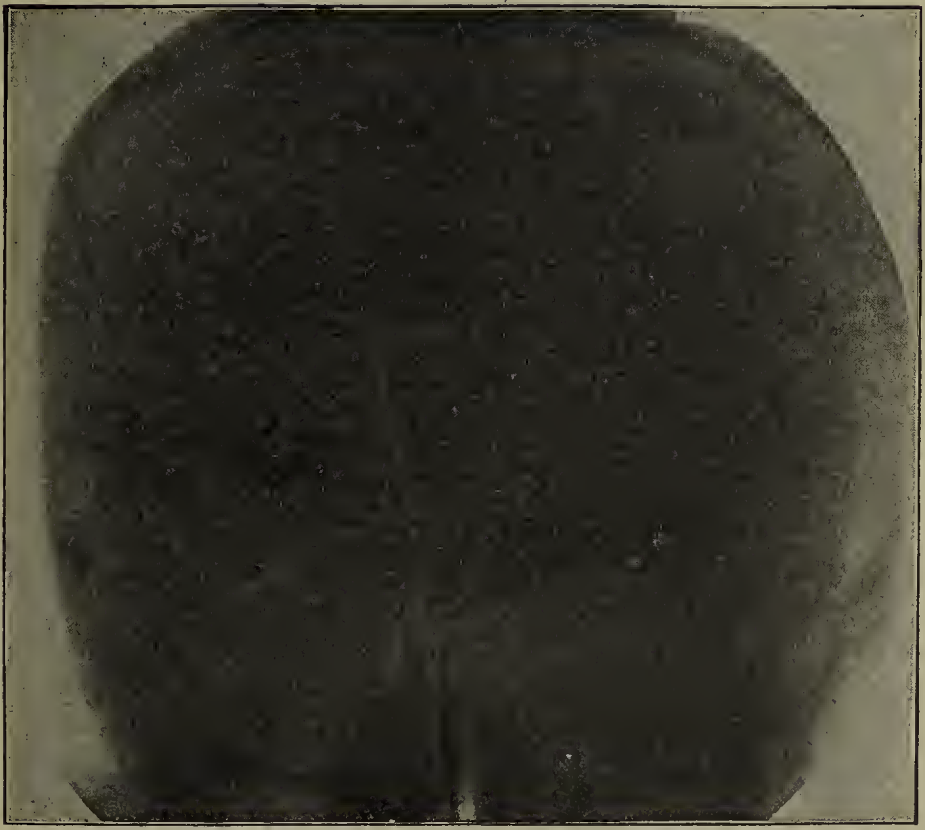

Fig. 154

December) to the time of the second X-ray exposure, the bullet had returned to the region of its entrance to the front. It now lay in the roof of the orbit a few centimetres from the frontal bone. It was found in the same position as observed at the examination on the 28th of January (at least five and a half weeks later). From this we may expect that the bullet will become encapsulated in this situation. The wandering of the bullet in the brain from posteriorly above to the front below has, according to the statements of the patient, produced no other symptoms, outside of brief periods of headache of the same character as at the time of the injury.

At other times again, bullets will produce manifestations of greater or less severity depending upon the sections of the brain involved. Occasionally, although rarely, the basal nerves are compressed. In these instances distinct symptoms are produced. If this be the case, we find a clear indication for the extraction of the bullet, which should be done immediately after its position has been ascertained by X-ray examination; for otherwise it would change its site again.

Like bullets, considerable parts of blades of knives may heal within the brain and remain there for a long time if not complicated by septic infection followed by the formation of an abscess (compare Observation X, 1, p. 845). If they remain without irritation it is best to leave them alone and they should be attacked only when causing disturbances. An example follows.

OBSERVATION XII, 4

Broken Blade Healed in Brain for Fifteen Years. Left-Sided Epileptiform Spasms. Extraction of Blade. Cure.

A machinist, thirty-two years of age, was referred by a Casualty Association to the Augusta Hospital for observation on account of epileptic spasms. When admitted he gave a history of having been struck on the right side of the head by a falling piece of metal while repairing a belt five years ago, and that he occasionally suffered from spasms since that time. His former attendants branded him as a malingerer. However, the X-ray examination taken by us threw light upon the situation. While at the hospital a number of left-sided epileptiform convulsions were observed in the face, in the abdominal musculature and slightly in the upper extremity. Since a number of smooth scars were found that indicated an old injury to the skull, on the right median portion of the head, two Roentgengrams were taken on the 4th of February, 1909 (from the side and from behind).

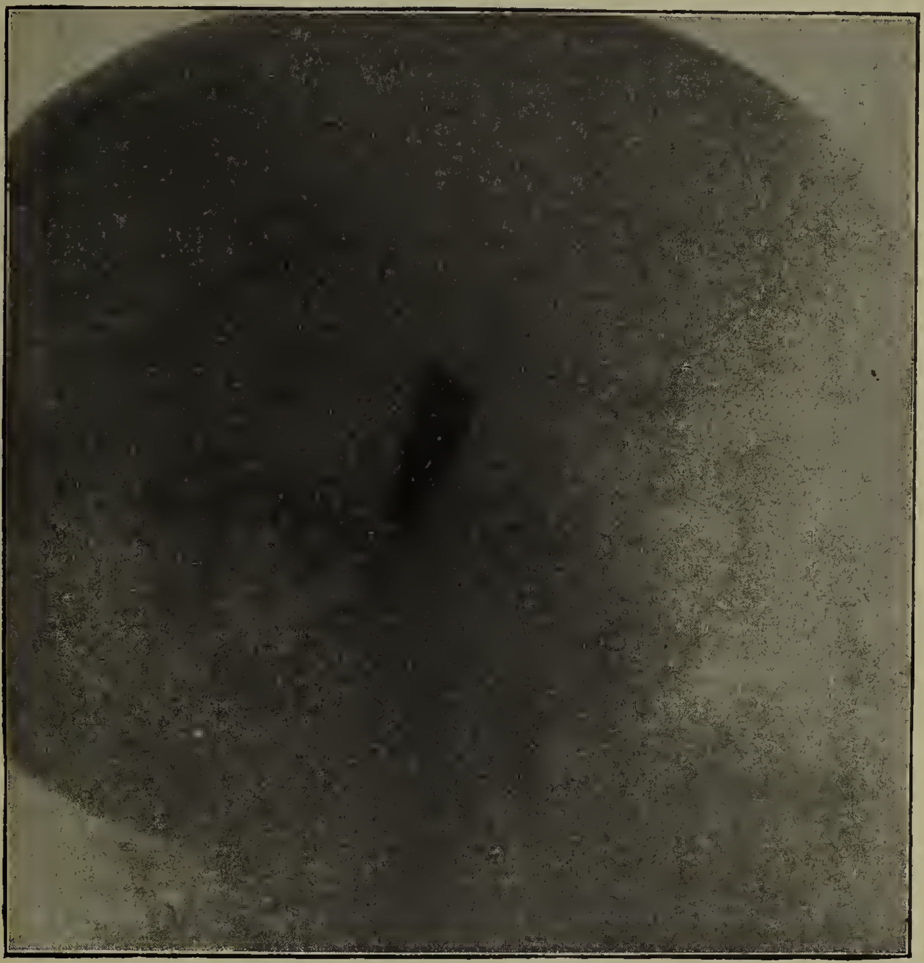

Fig. 155

Broken Blade of Knife Healed in the Brain for Fifteen Years
One-half natural size

These showed the presence of a broken blade of a knife in the form of a sharply outlined shadow. The base of the blade corresponded to the inner surface of the skull and its point was directed downward and forward toward the middle fossa of the skull.

The patient was very much surprised when the negative was shown to him. He did not have the slightest idee of the presence of a foreign body in his cranium. He was refused the payment of his benefits by the company for the reason that he was an alleged simulator. A few days after the operation when I showed him the blade of knife removed from his skull, he admitted that in 1903 (ten years prior to the accident referred to) he participated in a fight with knives when he sustained an injury to the right upper temporal region. Careful inspection of that place actually disclosed the presence of a scar about 1½ cm. in length. The blade had in all probability entered the skull at this place while the scars found in the right median region of the head, posteriorly, were probably due to the accident mentioned above.

An operation was undertaken on account of occasional epileptic attacks and headaches. The patient was trephined corresponding to the base of the right central region, so that the point of entrance of the knife (scar) corresponded to the middle of the trephined opening. After reflecting the osteoplastic flap, palpation showed the dura to be surprisingly smooth. It was fairly tense, however, and pulsating. No scar could be found on it. Retraction of the incision of the skin to an angle of about forty-five degrees and after the removal of the bone with a pair of rongeur forceps, a black metal body came to view with its broken end first. It was surrounded by a fairly dense capsule of grayish-yellow color. The dura was now split all the way around so that the entire focus lay exposed. A destroyed mass of cerebral tissue of black color was now visible and capsule and foreign body could together be carefully removed from the brain substance with dissecting forceps. For the sake of safety a strip of vioform gauze was introduced into the brain.

It should be added that the broken surface of the blade stuck partly in the dura and its presence was betrayed more by the black discoloration of the immediate vicinity than by its own protrusion. It was directed obliquely medianward, downward and forward into the cerebral tissue corresponding to the border of the anterior central convolution and the frontal brain. The wound was closed in typical fashion by separate suture of the periosteum and the skin. The strips of gauze were made to emerge from the anterior lower angle of the wound.

The black, rough-looking blade of the knife measured 4 cm. in length and 1.2 cm. in width. The opening made with the tre-

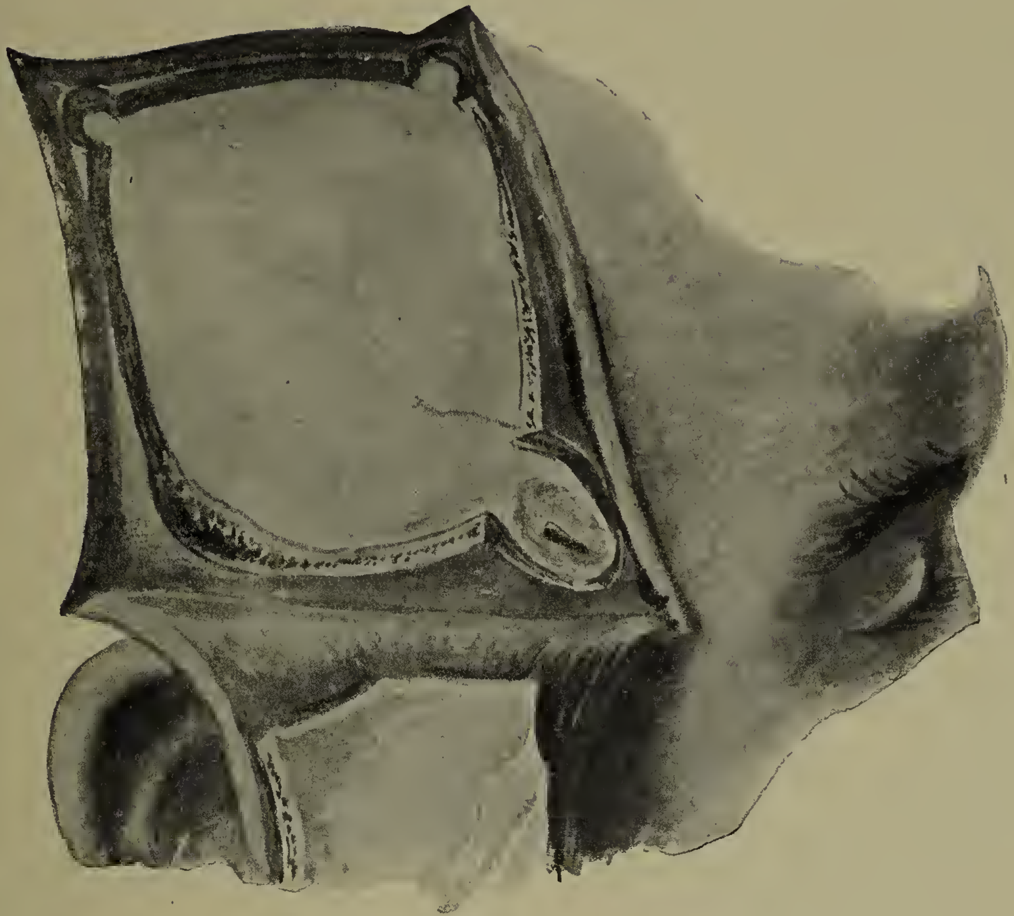

Fig. 156
$\frac{3}{4}$ natural size

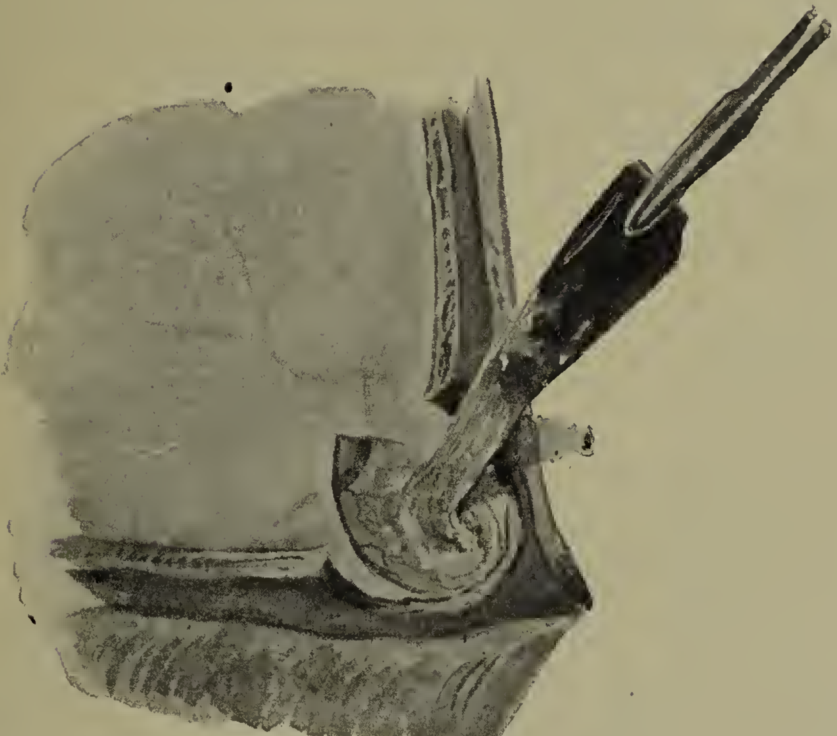

Fig. 157
Natural size

phine was originally placed too high. This mistake was occasioned by the X-ray pictures, despite two exposures. It would perhaps be best to have fashioned a flap as in extirpation of the *Gasserian* ganglion.

Immediately after the operation five epileptiform attacks were observed on the left side. They consisted of twitchings of the face and the abdominal muscles. Facial paresis was noted for a considerable period after each seizure. No further attacks occurred. There was no flow of liquor. The wound healed without disturbances. A paresis of the left upper extremity, occurring immediately after the operation, lasted only a short time. It had completely disappeared after twelve days. The patient left the hospital in the beginning of March, 1909, in excellent mental and physical condition. There were no paralyses.

The blade of the knife remained until the day of its removal fully fifteen years within the substance of the brain, without producing any local manifestations. The position of the large, sharp foreign body near the central region provoked occasionally epileptiform seizures. After the blade was removed, they recurred a few times and then disappeared. A peculiar fact observed in this case was the marked participation of the abdominal musculature of the opposite side. *Dr. v. Rad,* of Nürnberg, and I observed this only once in a case of very vascular gliosarcoma of the left upper parietal lobe. In this case strong clonic twitchings of the right abdominal muscles were observed in the beginning of the disease.

Treatment of Intracranial Hemorrhages

Intracranial hemorrhage not infrequently requires surgical assistance. Manifestations of cerebral compression will occur when the extravasation has attained a sufficient size. Since the development of symptoms of compression require a certain period, the time from the injury to the onset of these manifestations is spoken of as the *free interval.* This, of course, depends upon the nature of the vascular injury and it may range from parts of an hour to many days or even over one week. In the interval there are either no cerebral symptoms present, or the manifestations of cerebral concussion or, which is more frequently the case, those of compression may be noted. This emphasizes what has been said in the preceding pages: i.e., that the symptoms of divers cerebral injuries frequently merge into one another and give rise to a very complicated clinical picture.

Symptoms of pressure resulting from extravasations of blood do not differ from those occasioned by neoplasmata except that in the latter they are of insidious, and in the former of rapid, onset. In both, however, headaches, vomiting, disturbances of consciousness and changes in the pulse and respiration are noted. In hemorrhages choked disc is not very frequent.

With reference to the consciousness of the patient, progressive cerebral compression at first occasions an irritation of the cerebral cortex, hence states of excitement and delirium. Later on these symptoms recede and give place to apathy, somnolence and finally to total unconsciousness. The pulse is characteristically full and of high tension, slow and regular in the beginning. With reference to its frequency, individual fluctuations and the influence of temperature, if present, must be taken into consideration. In cases of increasing cerebral compression which leads to manifestations of paralytic nature, the pulse becomes small, fluttering and irregular. Until the paralytic stage is completely developed, the peculiarities of the pulse may differ so that it is now slow and again rapid. Corresponding to the action of the heart, the respirations are also slow, deep, and stertorous in the beginning, and later they increase in rapidity, become irregular and finally assume the *Cheyne-Stokes* type. In considering the frequency of the respiration individual conditions and other factors influencing its rhythm must also be taken into consideration.

Symptoms of irritation (headaches, slow pulse) predominate first. Later on signs of paralysis appear, until finally the latter alone are in the foreground of the clinical picture. Death closes the scene with the patient unconscious, and with a pulse such as described.

The local manifestations resulting from compression of certain portions of the brain are in the beginning also those of irritation. Extradural hematomata may give rise to *Jacksonian* spasms when situated in the central region. This has already been referred to in the chapter on *"Traumatic Epilepsy."* Manifestations of paralysis are sooner or later added to those of irritation. The symptoms of paralysis or irritation will depend upon the particular anatomic area involved, and to describe them in detail would mean a repetition of what has already been said. It may be briefly mentioned, however, that these consist of clonic and tonic muscular contractions which may also assume a *Jacksonian* character, paralyses occurring in the form of monoplegias and hemiplegias, exaggerated and abolished reflexes, aphasic disturbances of all sorts and hemianopic manifestations.

Dangerous hemorrhages may occur within or without the dura (intradural or extradural). The former by far more frequently originate from the arachnoid veins than from the cerebral arteries. Intradural hemorrhages are characterized by slow development, a longer free interval; also by the fact that they are not circumscribed, that they cause considerable irritation of the cerebral cortex and finally by the predominance of general symptoms of cerebral compression. Extradural hemorrhages occasionally result from torn vessels of the diploë, but they are mainly caused by an injury to the anterior or posterior branch of the middle meningeal artery or from some other large vessel which under increased pressure permits the rapid exit of a considerable quantity of blood. This explains the quicker onset of the manifestations. Since the uninjured dura is quite resistant, a circumscribed hematoma will result, between it and the inner surface of the skull; pressure is exercised on a certain part of the brain and distinct focal manifestations—if in the *Rolandic* region of motor nature—will result. The dura is in greater intimacy with the base of the skull than with the convexity, and will therefore tear with greater ease when there is an injury to the former, hence extravasations of blood are here (at the base of the brain), as a rule, intradural.

Besides injuries, considerable extradural hemorrhages are frequently observed in cases of pachymeningitis hemorrhagica, especially in alcoholics. These develop quite rapidly, the patients complain of severe headaches and apoplectic manifestations occur. Extradural hemorrhage may occur simultaneously with intradural bleeding. I have seen such cases a number of times. After removing the hematoma in such cases, the dura appears much darker than usual, it is bluish-red in color, transparent and, as a result of increased liquor, frequently fluctuating. Incision evacuates usually a thin sanguineous fluid intermingled with clots. After the removal of such extra- and intra-dural extravasations, the manifestations of cerebral compression and local symptoms quickly disappear, provided, however, that severe contusions of the brain do not complicate the condition.

The treatment of intra- as well as extra-dural extravasations consists of trephining. In this we are mainly guided by the symptoms present. Nothing is to be added here with reference to technic, but a few remarks on the treatment of the vessels require emphasis.

Simultaneous with the publication of my method of extirpation of the *Gasserian* ganglion (compare Plate XLI), I have recommended and successfully used the same procedure in a number of instances requiring ligation of the trunk of the middle meningeal artery. Since we are not in a position to judge with certainty whether it is the anterior or the posterior branch or, perhaps, the trunk of the artery that is injured, I have pointed out above by an example (Fig. 93, Vol. II, p. 504) that *Krönlein's* construction is not always dependable. In the case of that man the branches of the artery were, after the division, below 1½ cm. and above, 3 cm. distant from each other. For the ligation of the middle meningeal artery it is not essential to open the cavity of the skull. After temporary resection of the zygomatic arch, the arteria maxillaris interna is reached with ease and the middle meningeal may then be readily found and ligated. However, exposure of the middle fossa of the skull shows at the same time the extradural hematoma which in itself was the indication for the operation and which must under all circumstances be removed. Other surgeons, of whom *Steiner*, of *Wölfler's* clinic, was first, have followed my method of operating.

Cushing uses his temporal submuscular method (see Vol. I, p. 191) to drain the subdural space in basal fractures accompanied by hemorrhage. He asserts that he knows of no better way to reach an extradural meningeal bleeding or, as may be added, to drain an abscess of the temporal lobe than by the submuscular method.

SURGERY OF THE SPINAL CORD

All forms of paralysis of the spinal cord in which partial or complete interruption of conduction is caused by trauma or by compression of the cord, are subjected to surgical treatment. Pressure paralysis may result from any cause which restricts the space within the vertebral canal, be this consequent to a neoplasm of the cord or its membranes or secondary to various diseases of the vertebræ. While operations on the spinal cord for injuries have been performed for many years past, the credit of deliberate exposure of the cord for tumor belongs to *Victor Horsley*. This observer has, together with *Gowers*, opened a hitherto unexplored field by successfully removing, in 1887, a tumor of the dura mater spinalis. *Ernst v. Leyden*[1] was first to refer these cases to the surgeon. He was fully aware of the difficulties and dangers of the operation, but in the face of the total hopelessness of the condition, he ventured the attempt in a certain case.

The number of successful cases has of late increased from year to year. These successes are in a measure due to the refinement of surgical technic and to the progress made in the treatment of wounds. Equally as much credit is due to the extraordinary attainments in the field of diagnosis in the last decade or so, during which not only the diagnosis of the existence of a tumor was made possible, but we were in many cases successful to exactly locate the site of the neoplasm by means of the so-called segmental or level-diagnosis. With such knowledge at hand, the shortest way to the surgical attack is pointed out, for the less vertebral arches are removed, the less damage is done by the operation.

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[1] Die Klinik der Rückenmarkskrankheiten. Berlin, 1874, Band 1, p. 467.

Opening of the Vertebral Canal by Laminectomy

Preparation of the Patient and Time of Repair

Position of Patient

In order not to interfere with the action of the heart from compression, I have in the majority of my cases placed the patient in the right lateral and in the half-abdominal position. Despite all precautions, however, the unavoidable pressure on the thorax will influence the cardiac action and the respirations to a certain extent. In order to avoid this as much as possible, the patient will have to be carefully retained in position by assistants holding the pelvis and shoulders, and he is made to assume the pure lateral position from time to time. This precaution is of special importance when the patient is in the left lateral position in operating for suspected neoplasm compressing the right side. Long continued compression is dangerous. I have seen a man, thirty-five years of age, perish under all manifestations of insufficient respiratory function soon after an operation for a meningitis serosa, during which an extraordinarily slight quantity of blood was lost and the operation itself was comparatively trivial (see Observation XIV, 2). It is to be remarked, however, that the patient in this instance was a sufferer a few years ago from pulmonary catarrh and hemoptysis. If a voluminous pillow be placed under the pelvis of the patient while his shoulders rest on the operating table, the thorax will almost entirely be liberated from undesirable pressure.

Access to the field of operation is rendered considerably less difficult when the spinal column is brought into a position of kyphosis. This is enhanced in the cervical and thoracic portion of the spine by proper position; i.e., head and chest leaning forward. In the lumbar region this is effected by having the lower extremities semiflexed at the hips and knees and the pelvis brought to the edge of the table. During the operation the patient should be wrapped in warm, woollen blankets, resting on a thermophor pillow. This obviates collapse which may result from the exposure of such extensive areas. The temperature of the operating-room should be between 24° and 28° C.

What has been said of

Anaesthesia, Asepsis and Dressing

when speaking of surgery of the brain (consult Vol. I) is also applicable to operations on the spinal cord, with the exception that in the latter we may use ether as an anæsthetic instead of chloroform. In a number of cases I have also used local anæsthesia by infiltrating the parts with ½% solution of novocain and 1% solution of adrenalin (15 drops or more to each 100 cm^3. of solution), prepared in the manner recommended by *H. Braun.* The solution is injected into the tissues a few fingers above and below the spinous processes to be exposed. In order to render the skin insensitive to the deep punctures, it is recommended that after making a few wheals in various places of the skin, the cannula is at first introduced to the arch of the vertebra laterally to the spinous process, and while the syringe is being elevated and depressed, 5 cm^3. of fluid is injected each time above, below and to the side. The needle is then somewhat withdrawn, and the other side of the spinous process is injected in a similar manner. Before the needle is removed, the skin must be rendered entirely insensitive by injecting the subcutaneous fat. The other end of the field of operation is treated in the same manner. If it appears before the operation that a number of vertebral arches will have to be removed, the injection should proceed from the middle of the field of operation and the fluid injected on all sides.

The incision of the skin and muscles as well as the detachment of the periosteum from the spinous processes and arches is entirely painless. The hemorrhage is also practically *nil.* Drilling of the arch is painless, but the detachment of the dura from the inner surface of the arch and its division with the laminectome is perceived by the patient as often as the instrument comes in contact with the dura. If the latter be avoided, the biting off of remnants of bone with the rongeur forceps is barely felt by the patient. Extradural probing, however (between arch and dura), is accompanied by pain which is also perceived when sponging the dura and at every contact with the posterior surface of the cord, especially the posterior spinal nerve roots. The laminectome is a useful instrument in operations under local anæsthesia, because it divides the arch neatly and without much trauma. Local anæsthesia, however, is only effective in patients who can exercise a certain degree of self-control. The majority of patients will be alarmed and may even get into a state of terror and harmful psychic excitation when hearing the sound produced at the division of the arches, even though they perceive no pain whatever.

Since *Braun's* local anæsthesia insures almost complete absence of pain, it is hardly necessary to resort to *Bier's* spinal anæsthesia. I have not ventured to make use of it personally in the presence of compression of the cord.

One more word with reference to asepsis and dressing. We are occasionally forced to operate in the presence of decubitus. In cases of compression of the cord its complete cure is rare in the majority of cases and we cannot afford to postpone the operation until the wounds are cleaned. It is fortunate, however, that with the exception of compression of the cauda equina, these ulcers are mainly situated much lower than the region of the cord to be exposed. Immediately before the operation the ulcerated parts are covered with long, tile-shaped strips of adhesive plaster. Even under unfavorable conditions the method of *Grossich* (painting the skin with tincture of iodine) offers perfect security. In operations on the skull and spinal cord I have employed this method of disinfection, exclusively, in all of my cases for the last two years. Since the application of this method requires a perfectly dry skin, the field of operation should be prepared at least twenty-four hours before the patient comes to the operating table, by a cleansing bath, shaving and, perhaps, a preparatory disinfection which, however, is not absolutely necessary. This simple procedure has proved very efficient even in the following unfavorable instance.

A man, sixty-two years of age, afflicted with a neoplasm in the region of the cauda equina, was suffering for a number of months from an ichorous decubitus larger than the palm of a hand, which extended into the depth of the sacrum. Treatment with baths, applications and salves for a number of weeks resulted in the casting off of the necrotic tissues, and a tolerably granulating surface resulted. The opening of the vertebral canal and the dural sac in the region of the 3d and 4th lumbar vertebræ could no longer be postponed on account of the severity of the original trouble, and the operation had to be performed about two fingers above the undermined and profusely suppurating decubitus ulcer. In order to attain dryness of the skin, baths had to be dispensed with a number of days before the operation. Painting of the skin, the ulcerated surface and the suppurating pockets with tincture of iodine resulted in perfect disinfection, so that immediate suture of the dura and the wound of the muscles and skin healed per primam with an ideal scar. No drain whatever was used.

After the operation is completed, the dressing is also applied against the decubitus, and it is carefully closed up by means of strips of zinc oxide adhesive plaster. I was in this manner successful to keep the wounds in an aseptic condition if the dressings were not continually saturated with urine (see *Prognosis of Laminectomy*). The dressings of the wound after the operation consists of sterile gauze and absorbent cotton. These are retained in position by square strips of adhesive plaster between which spaces are left for cutaneous evaporation and to keep the dressings dry. The latter are in most cases permitted to remain until the healing of the wound is complete (ten to fourteen days). The sutures are removed at that time. If, as exceptionally happens, there is a flow of liquor, the dressings must be changed daily. In such cases they are best kept in place by a sterile towel pinned in the front.

The time for repair in aseptic cases united by primary suture is comparatively brief. After fourteen days no more dressing is needed (in the absence of a flow of liquor). Patients operated on in the upper sections of the vertebral column may at that time leave the bed. In more extensive operations, when four or more vertebral arches were removed from the lower part of the spinal column, the patients will necessarily be bedridden for a longer time. If the case be complicated by a flow of liquor, the patient should never leave the bed before the wound ceases to secrete.

Laminectomy

The spinous process which clinically corresponds to the vertebra selected for the surgical attack is marked the day before the operation with silver nitrate. Where a thick panniculus adiposus is present the counting of the vertebræ will be quite difficult. In such cases this is hard at times even when we commence counting from the vertebra prominens (7th cervical). If the head of the patient be flexed on the chest as far as possible, the spinous process will usually be made prominent. It must be remembered, however, that the 6th cervical vertebra may frequently form quite a projection. For the sake of safety, therefore, I recount from the 12th rib or from the last lumbar vertebra upward. Where a curvature of the spine, no matter how slight, complicates conditions, orientation will be rendered more difficult. Operations under these circumstances offer, in many cases, serious obstacles.

I expose the vertebral column by a longitudinal incision which is at once carried down to the points of the spinous processes. Its length depends upon the number of vertebral arches we wish to resect. In some of my cases it was occasionally 27 cm. in length.

The lips of the wound are well retracted and the fasciæ and muscles on one side of the spinous processes are divided with a knife down to the vertebral arches, and the profusely bleeding wound is rapidly packed with gauze dressings. While an assistant forcibly compresses the wound, the other side is treated similarly (tamponed and compressed). After a few minutes the bleeding almost invariably ceases to such an extent that not a single vessel need be attended to. Secondary ligation of vessels was only rarely required. Only little blood is lost during this manœuvre.

The wound is kept apart by means of wide retractors and a strong and extra wide raspatory exposes the posterior surfaces of the vertebral arches. In these cases I invariably sacrifice the arches, for I am of the opinion that it is an entirely unnecessary hindrance at the operation to endeavor to retain them. The supporting power of the vertebral column does not suffer by the removal of even as many as seven arches. I was able to observe this in two cases operated upon with satisfactory results (compare Observation XV, 4). At least the damage done is not of sufficient magnitude to render the dangerous operation still more hazardous. The observations referred to were operations on the thoracic vertebræ. I have also removed a number of times four arches in the cervical region (compare Observation XIII, 2) without disturbing the mobility and the power of carriage to any appreciable degree.

Only two arches should be taken away at first (except in the lumbar region), and, if need be, the number increased later. Greater exposure is required in instances where the tumor had spread laterally into the ligamentum denticulatum or toward the front of the cord (rarely the case) in which event it is lifted out with extreme care after splitting the dura.

The landmarks leading to the recognition of the desired vertebral arches are the spinous processes. However, only in the cervical and lumbar regions have these spinous processes nearly a horizontal direction, and therefore lead directly to the arches. In the dorsal region, on the other hand, the spinous processes run obliquely in roof-tile fashion and the longer ones may deviate to the side. The tendency to obliquity is most marked in the middle portion of the thoracic region so that, for instance, the spinous process of the 7th occupies the same horizontal position as the upper portion of the body of the 9th vertebra. In order to remove the desired vertebral arch we must be guided by the spinous process, following it up from a silver stain marking it on the surface to the depths. The 9th arch, for instance, is entirely covered by the 8th processus spinosus, and in order to expose the dura in the region of the former, it will also be necessary to remove the latter. As a rule, I do not remove the processes. They are resected only when their obliquity and length interfere with the necessary steps of the operation, and even then only superficial portions are taken away. When retained they act admirably as levers for further manipulations.

As in operations on the skull, I have ceased using the chisel in my work on the vertebral column. Since, however, this simple instrument is occasionally used with good effect in emergencies, I shall mention the technic previously practised in my clinic. The arch of the respective vertebra is first carefully divided at one and then on the other side with a chisel not too distant from the spinous process. While the latter is seized with a *Langenbeck* forceps and strongly pulled upon, the soft tissues still attached to it, especially the strong intercrural and interspinal ligaments, are divided. The chiselled median portion of the arch may now be completely detached with a few snips of the scissors, and the vertebral canal is now exposed to view in the depth of the retracted wound. The lateral remnants of the arch are removed with rongeur forceps. The division of the adjacent arches is facilitated by introducing a thin, curved elevator through the vertebral canal in an upward direction, and under its protection the arches are cut through. The sharp borders are rounded off with the rongeur forceps.

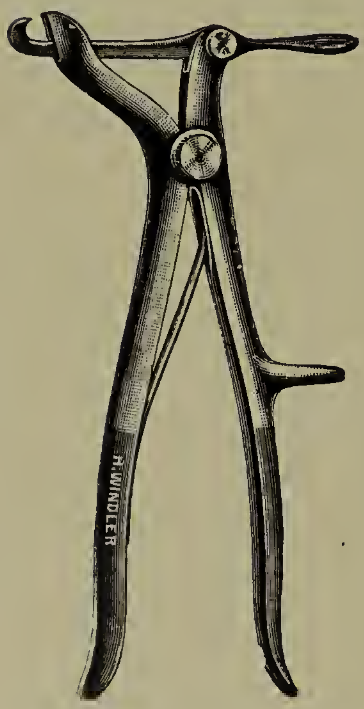

Fig. 158
Krause's Laminectome
⅓ natural size

Instead of the chisel, the division of the arches is accomplished by means of my laminectome (see Fig. 158) which is built on the principle of the *Dahlgren* forceps (Vol. I, Fig. 7, p. 17). On either side of the exposed spinous processes an opening is drilled with the *Doyen* instrument carrying a medium sized burr (see Vol. I, p. 14). I now carefully introduce the cutting hook of the laminectome into the opening and insinuate it underneath the arch, and while the embracing fork of the other arm of the forceps steadies the hook by pressure upon the long upper lever, the arch is cut through. A preliminary detachment of the dura mater, as practised on the skull, is here unnecessary because a layer of epidural fat of greater or less thickness separates it from the inner surfaces of the arches. For the sake of greater security, this is accomplished with the smallest *Braatz* sound (see Vol. I,

p. 15, Fig. 5) or a half-pointed curved elevator. The same manœuvre is carried out on the other side. It is also practical to divide, besides the osseous arch, the ligamentum flavum attached above and below. If the adjoining interspinous ligaments are divided with the knife, the spinous process seized with *Langenbeck's* forceps and the arch pulled to the front, its removal is accomplished with ease. Great care should be exercised that no pressure is exerted upon the cord during the various manipulations.

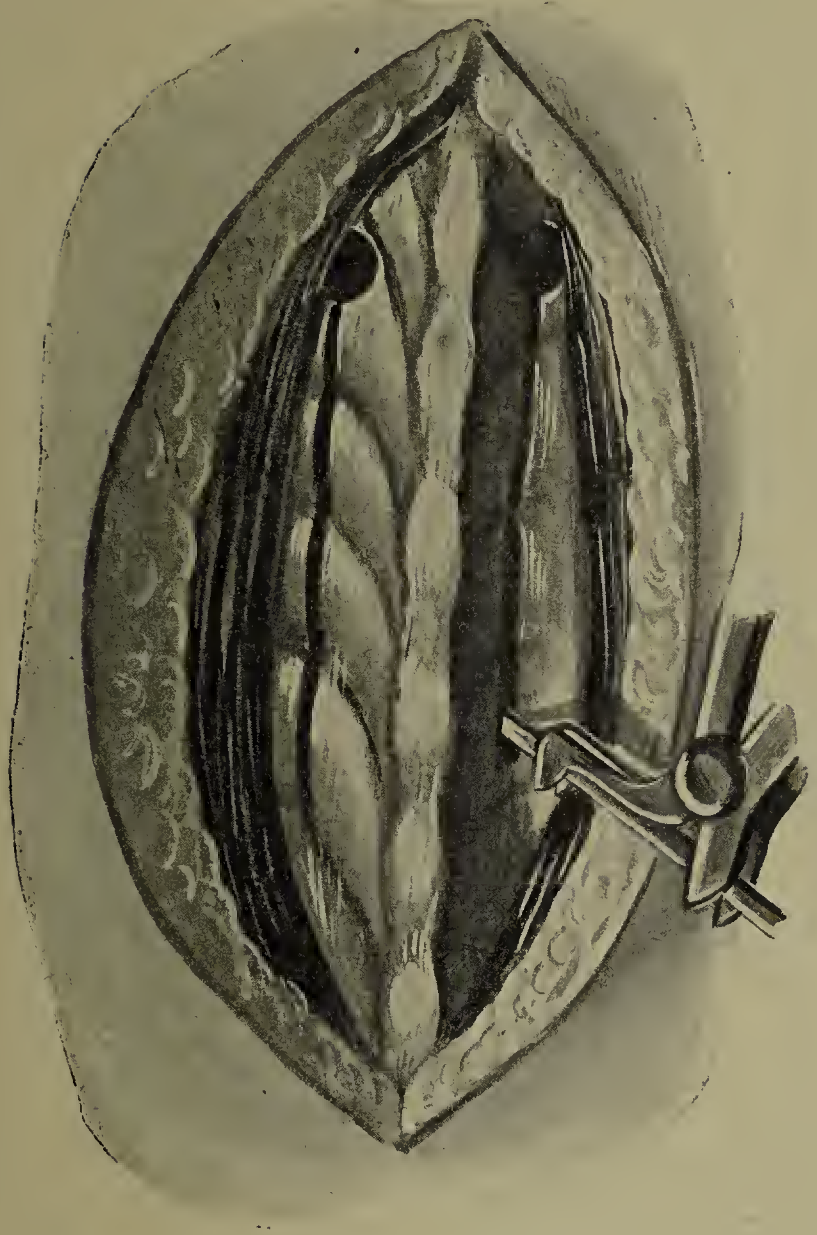

Fig. 159

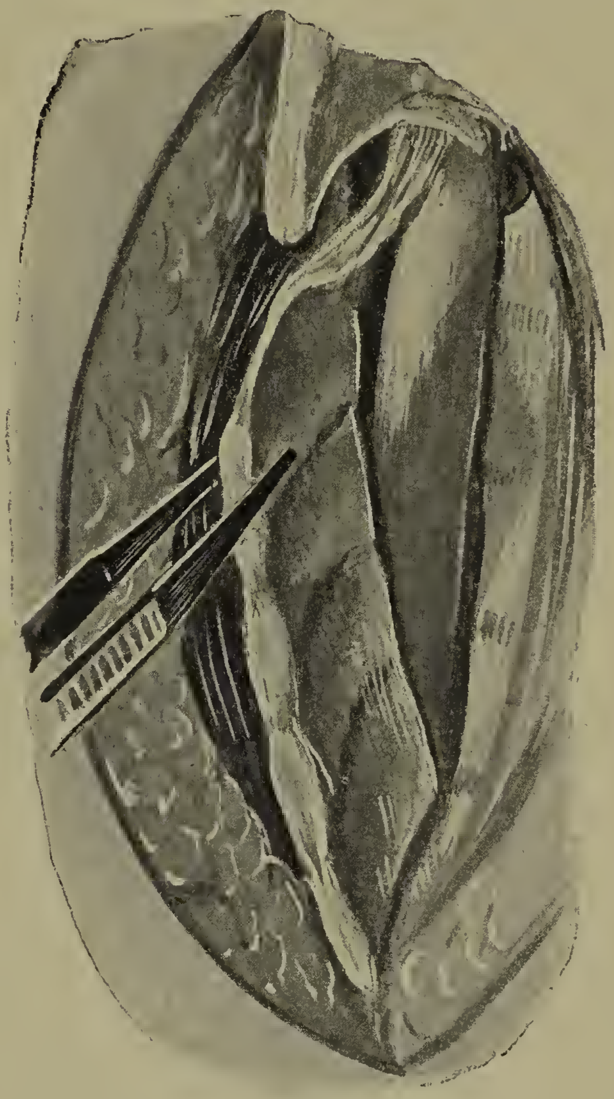

Fig. 160

In the cases where the removal of a certain number of arches is contemplated beforehand, as for instance in the resection of the 7th to the 9th, or 10th pairs of posterior dorsal roots, in cases of tabetic crises or in the resection of the 2d to the 5th arches of the lumbar vertebræ for excision of the posterior lumbar and sacral roots for spastic pareses of the extremities *(O. Förster)*, I remove the entire posterior wall of the vertebral canal in one piece. To accomplish this, it is only necessary to bore a hole on either side of the spinous process of the uppermost or lowest arch to be resected and then to execute two parallel incisions with the laminectome which divides the osseous substance of the arches and the intervening ligamenta intercruralia, and the entire posterior wall of the vertebral canal is thus removed in one section. Even with this method the cord was not injured, because the careful introduction of the hook into the vertebral canal, the intervening epidural fat and the natural intradural space protect it from traumatization.

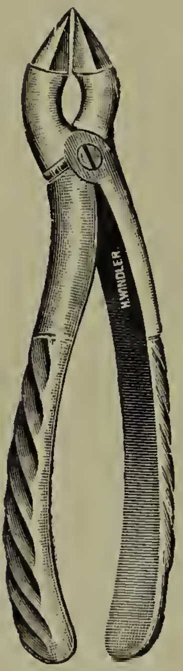

Fig. 161
⅓ natural size

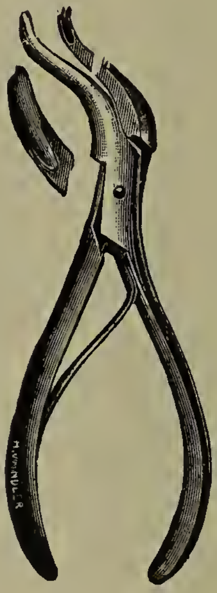

Fig. 162

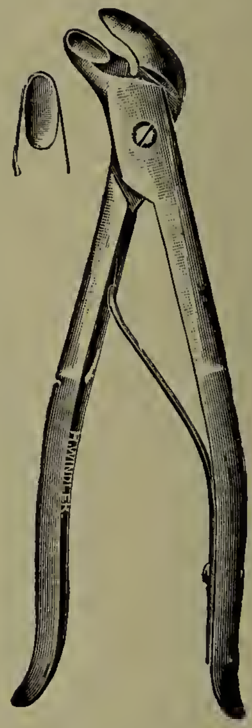

Fig. 163
⅓ natural size

In tumors or similar processes this method is not advisable, because if only one arch is removed, inspection of the dura and proper probing for purposes of orientation show us the way to continue to operate (in an upward or downward direction). There is one objection that may be raised against the cutting hook, and that is that it has to penetrate into the vertebral canal in cases where the space of the spinal canal may be extremely restricted by the presence of a tumor and that it may thereby exercise undesirable pressure on the cord. While in my experience no untoward symptoms followed its use even in large tumors, I will, nevertheless, permit the objection to stand.

I very rarely make use of *Horsley's* large cutting forceps (Fig. 161 depicts one-fifth of its natural size). With this instrument, the arches are divided from without inward and without encroaching upon the vertebral canal. I recall a case where the 5th to the 8th arches of the dorsal vertebræ had to be removed, in which *Horsley's* instrument disappointed me, and my cutting hook was successful in dividing the parts which were extremely hard. In other cases again, I was able to divide with these forceps arches of lumbar vertebræ in a slow, gradual manner.

As in all other technical procedures, practice in the use of a particular instrument is of paramount importance. Personally I prefer my laminectome. This instrument has especially demonstrated its utility in a case of high degree of malformation of the ribs in which the neck and the tubercles were mainly affected, and in which the distorted transverse process restricted the space to an extraordinary degree. Another advantage in the use of the cutting hook is the fact that there is no hemorrhage from the cut surface of the bone. This is due to the fact that there is no actual cutting but a division by pressure. This was nicely demonstrated in the case of a girl seventeen years of age in whom the division of the soft parts and the cutting of the bone with the rongeur forceps was followed by hemorrhage of such a degree that the operation had to be performed in two stages. On the other hand the portions of bone severed with the laminectome hardly bled. In this case *Passow's* chisel (see Vol. I, Fig. 11, p. 23) was used to great advantage. A few smart blows on the lamellæ of bone will cause even marked arterial hemorrhage to cease.

The spinous processes and posterior arches may finally be taken away piecemeal with rongeur forceps of various sizes and shapes (see Figs. 162 and 163), a procedure against which nothing can be said except that it is tedious.

One principle should always be adhered to, regardless of the method used, i.e., the vertebral canal should be widely exposed in every instance (to the articular and transverse processes); the object being to permit the necessary accessibility. If remnants of the arches remain, they should be bitten off with the rongeur.

At times conditions may be quite difficult, especially when the patient has undergone one or more unsuccessful operations, as I have seen it happen thus far four times. While under normal conditions we may boldly cut down on the spinous processes and then separate the soft tissues to the right and left from the lateral sections of the posterior surfaces of the vertebral arches, in the cases just referred to, great care must be exercised lest the dural canal be opened into. The old scars are in such instances carefully dissected in the median line, layer after layer, until the dura which is always blended with the superimposed structures is reached. Observations VIII, 2 and 4, and XIV, 1, illustrate such cases. It is best in such instances to isolate an arch not as yet touched by a previous operation above or below the old scar, and the dura in this situation is bared with drill and burr. After ascertaining the depth at which the remainder of the operation will have to be performed, the procedure is continued in the usual manner by means of a probe and a couple of dissecting forceps. The history of the three cases referred to will be given later on.

Relation to the Dura

After the vertebral canal is widely opened and the epidural fat incised in the median line and together with the venous plexus bluntly pushed aside, we are face to face with the dura mater spinalis. If the case requiring operation is one of extradural neoplasm, the tumor is now recognizable and after rendering the vertebral canal sufficiently accessible, it may be removed. I have enucleated an enchondroma that sprung from the 6th cervical vertebra by means of a sculptor's chisel (compare Observation XVIII, 1, Plate LXII). However, if we are dealing with an intradural neoplasm, as is usually the case, the dura and its vicinity will almost invariably be found very tense on account of the accumulation of liquor.

The collection of fluid in these instances is mainly found above the tumor. Yet, I have seen it a number of times below it. I recall the case of a man, forty-six years of age, in whom the tumor extended from the arch of the 7th cervical vertebra to the arch of the 2d dorsal, and in whom the dura at a point corresponding to the arch of the 3d dorsal vertebra was so tensely filled with fluid that it looked like a thin-walled hydrocele, permitting light to penetrate it, while above the tumor no liquor was found.

Now with reference to *pulsation of the dura* we find that in normal conditions, as seen, for instance, in resection of the posterior roots, they are very slight to the naked eye. At times we find the pulsations correspond to the action of the heart, and at others they are synchronous with the respirations. In cases of intradural neoplasmata with accumulation of fluid, not the slightest pulsations are observable. If the liquor be evacuated by a small incision, distinct pulsations will be seen which are mainly synchronous with the heart-beat and more rarely with the respiration. In the case just mentioned pulsations that are isochronous with the respiration were noticed after the stagnating liquor was drained off and the 2d and 3d arches of the dorsal vertebræ resected. The exposure of the tumor in this instance necessitated the removal of the arches of the 1st thoracic and the 7th cervical vertebra. After this was done the tumor was felt to pulsate together with the spinal cord through the dura isochronously with the respiration and with the pulse. In cases where no accumulation of liquor has taken place, we occasionally see pulsations, before the dura had been opened, at the side of the tumor, mainly below.

At times again, we find the place where the dura has been opened to be of normal appearance, tension, and pulsation. In such cases we must decide whether the removal of the vertebral arches should proceed in an upward or downward direction. To decide this we make use of

Extradural Probing

An olive-pointed probe of medium size gives the best results. It may be introduced for considerable distances in both directions on the posterior surface of the dura between it and the bone, without damaging the parts. The conditions restricting the lumen may in this manner frequently be discovered. If such probing be negative, we must continue the procedure to the right and left between the dura and wall of the vertebral canal, while in the latter situation the greatest possible care should be exercised on account of the spinal roots. Extradural probing does not always lead to the point sought. The probe may glide over the place occupied by an intradural neoplasm without meeting with the slightest resistance. I recall of having removed a neoplasm, 35 mm. in length, which was intimately blended with the inner surface of the dura. It was firm and of the thickness of the little finger and situated in the region of the arches of the 8th and 9th dorsal vertebræ. Introduction of the sound intradurally to the level of the 7th arch disclosed the obstacle. Negative results at extradural probing are, therefore, not conclusive evidence of the absence of pathologic conditions.

It is best to adhere to the principle to open the dura under all circumstances, even if it appears normal. It will be remembered that the same rule is followed in operations upon the brain.

The only exception to this rule are the cases in which the tumor springs either from the bodies of the vertebræ or from their arches and fully explain the symptomatology of a given instance.

But even in such cases it appears to be the safest to open the dura. I remember the report of *Nonne* at the Second Congress of German Neurologists at Heidelberg, on the 4th of October, 1908, in which he related a case of extirpation of an extradural neoplasm by *Sick* who discovered the presence of an intradural tumor upon opening the dura. I have removed a flat extradural neoplasm from the thoracic portion of the vertebral column in a woman, forty-five years of age, the microscopic examination of which proved it to be an inflammatory process of the external layers of the dura and of the epidural fat. Besides this, opening of the dura at the level of the 7th, 8th and 9th arches of the vertebræ showed a marked meningitis serosa. Had the dura not been touched, this apparently secondary process would have continued, and the severe manifestations of compression of the spinal cord perpetuated.

I have thus far reoperated on four patients in whom operations had been performed by prominent surgeons without success (in one case twice) because they halted at the dura. In two of these cases I have extirpated extradural neoplasmata (see Observation XIII, 2 and 4), and in two others (for instance, Observation XIV, 1) severe changes of serous meningitis and chronic arachnitis were found. In one case I collected 120 gms. of fluid, besides a considerable quantity which was lost. After all of the fluid is drained off, the dura mater is enlarged lengthwise, corresponding to the entire extent of the wound and, if a neoplasm be present, it will at once come to view, especially when situated posteriorly. Enlargement of the wound and the removal of one or more arches is frequently necessary. The wound in the dura is best retracted by hooking vulsella forceps to the cut borders and pulling them apart.

Relation to the Spinal Cord

If the tumor is located laterally to the ligamentum denticulatum, a long, narrow line of grayish-red color frequently marks its presence. The careful introduction of a blunt hook lifts the cord somewhat to the surface, and the neoplasm wedged between it and the dura is brought to view.

The arachnoid frequently continues from the cord over the neoplasm which it surrounds in the form of a capsule. If it be grazed with the scissors, the tumor together with its capsule may then be bluntly removed from the cord without difficulty. If the tumor is found to have originated from the inner surface of the dura, it should be removed to the entire extent of its attachment.

The neoplasm usually rests in a cavity or trough of the spinal cord the size of which corresponds to that of the tumor. If a trough be present, the cord is usually flattened and, after the removal of the new growth, it resumes its rounded form again. The portions of the cord immediately above and below the impression made by the tumor remain for a time thinner. It is astonishing how quickly deep hollows representing the bed of the tumor will in some cases become filled out before our eyes, even during the operation. In a case (Observation XIII, 4, Plate LI) in which a post-mortem examination was made two days after the operation, not a trace was found of a very deep trough in the cervical cord. At other times again, for instance in Observation XIII, 1, Plate XLVIII, Fig. a, in which there was spherical excavation in the dorsal section of the cord, not the slightest tendency to rectification of the depth of the cavity was observable during the operation.

Intradural Probing

If after opening the dura mater the suspected neoplasm is not found, intradural probing in an upward and downward direction should be resorted to. This may be done with olive-pointed probes which are guided with the greatest possible care to either side and to the front of the cord.

Special attention should be paid to the spinal nerve roots. Proceeding thus, I was repeatedly successful in discovering the obstacle. It should be kept in mind that in probing laterally to the cord, the probe will easily be caught in the ligamentum denticulatum. If we desire to explore the anterior surface of the cord, a blunt, rectangular vulsellum will greatly aid us by pulling it gently forward. In rare instances in which the intradural neoplasm develops on the anterior surface of the cord, it will be necessary, in order to successfully extirpate the tumor, to make use of two blunt-pointed strabismus hooks, one of which is applied above and the other below the neoplasm which is now lifted upward and displaced a little to the side. That extreme care is to be exercised during this manœuvre, needs hardly to be emphasized. If the posterior surface of the bodies of the vertebræ are to be exposed, as is the case in caries, fractures with exuberant callus formation, projectiles, and similar conditions, the cord, together with the dura enclosing it, is lifted up and displaced laterally. This is best accomplished with a half-pointed elevator of almost circular form, curved flatly, with which the dura is separated from the bodies of the vertebræ. The spinal nerve roots should be protected from injury as much as possible during this procedure. In this, however, we will not always succeed, especially with the posterior roots. Division of a root in the thoracic cord is not a very serious accident. In the cervical and lumbar region, however, considerable disturbances will follow, especially when a number of adjoining pairs of roots or motor-nerve roots are interfered with.

In one instance (Observation XIII, 5) I was unable to detach the dura bluntly and could not therefore reach the extradural tumor of the body of the 3d lumbar vertebra which projected into the vertebral canal. The cauda equina was therefore lifted up with a narrow hook, the anterior dura incised in a longitudinal direction and the enchondromatous neoplasm successfully shelled out.

Care of the Wound

After the hemorrhage has ceased at the conclusion of the operation, it is best to close the wound with sutures. If the dura mater was not subjected to much injury, the longitudinal incision made into it, is united with a few interrupted sutures with very fine boiled linen thread. This, however, is impossible when a strip of dura or even more has been excised on account of its adhesion to the tumor. In such cases the area of the spinal cord corresponding to the adherent region is left uncovered, while the rest of the dura is sutured, wherever possible. The deep muscle wound is united in every instance by three or more catgut sutures which are introduced to the very bottom (to the posterior surface of the arches). Over this the skin is sewn without drainage. In aseptic wounds complete closure should be aimed at as much as possible.

If the hemorrhage, on the other hand, was not completely arrested, it is best to introduce a short drain into one of the angles of the wound. In order to avoid the unpleasant and occasionally serious flow of liquor cerebrospinalis, this drain, it must be remembered, should not project to the wound of the dura. Complete closure of the wound prevents this, very effectually, although not with absolute certainty.

I recall the case of a patient, twenty-three years of age (see Observation XIII, 2), in whom the dura of the cervical cord had to be excised from the arch of the 5th vertebra upward to the lower border of the atlas. The neoplasm was so extensive and growing externally that the entire posterior width of the dura had to be removed. Seven days after the operation a fluctuating accumulation of liquor was discovered under the wound of the soft tissues, which healed per primam. On the eighth day the sutures were removed. On the ninth day after the operation a suture tract of the wound opened from which clear liquor was discharging from that day on, for a period of three weeks. The quantity of fluid draining off was variable. For instance, on the fifteenth and sixteenth days after the operation the dressings were found perfectly dry. At other times again, while changing dressings, a steady stream of clear fluid was seen dropping from the tract alluded to. Occasionally, not only the voluminous dressings but the bed also was thoroughly saturated from the flow of liquor cerebro-spinalis. With rare exceptions the dressings had to be changed daily, a procedure which was very annoying to the much affected patient. The skin surrounding the wound was carefully sponged off each time with sterile gauze dipped in ether. It was finally possible with great difficulty to cure the patient by rigid asepsis. After the sixteenth day the flow of liquor diminished and on the twenty-first day it had completely ceased. The small fistula was at no time cauterized with silver nitrate. I do not permit cauterizations in my work, because it creates an undesirable superficial necrosis. Such wounds must remain perfectly clean. They close by the contraction of the scar. For disturbances following stagnation of liquor and excessive discharge of this fluid, compare corresponding chapter.

To avoid the excessive flow of liquor cerebro-spinalis during the operation, *Sick* recommended the encircling of the dura with a ligature. If we could ascertain the extent of the tumor and its position before opening the dura, a ligature applied with a moderate degree of constriction would, perhaps, be beneficial. However, not infrequently, a number of vertebral arches must be removed during the operation which, of course, necessitates the loosening of the ligature again, and since the thread must be removed at the conclusion of the operation, it does not protect the flow of liquor during the period of healing. Thus far I have not made use of *Sick's* method. The dura should at first be opened a very little, as this prevents too rapid evacuation of the liquor. The opening is enlarged after the fluid present has drained off. The flow of liquor during the operation is, as a rule, slight. Should the flow be excessive, as exceptionally happens, slight compression of the sac of the dura above and below the field of operation with gauze dressings will suffice to arrest it.

Wherever possible operations upon the spinal cord should be performed in one sitting. In a series of forty-five laminectomies for neoplasmata or manifestations simulating tumor I was compelled to interrupt the operation twice. In one of these cases eleven days, and in the other three and a half weeks elapsed before the operation was concluded. In the first case the arches of seven dorsal vertebræ were removed, and the patient was in too weak a condition to stand the severe operation in one sitting. The case was one of tuberculosis in which after the 7th to the 9th arches of the dorsal vertebræ were removed (compare Observation XV, 4, Plate LIX), the whole wound was tamponed with iodoform gauze and the skin sutured over it. The operation was resumed after an intermission of eleven days and the arches of the 4th to the 6th and the 10th dorsal vertebra removed. In the second case the division of the operation into two stages was necessary on account of severe bleeding. The case was that of a girl seventeen years of age who developed, in the course of two years, manifestations of a complete transverse paralysis. Of the objective symptoms a loud vascular murmur, audible over a great portion of the back, was in the foreground of the clinical picture. Since its greatest point of intensity corresponded to the region of the spinal column in which compression was suspected, the possibility of a vascular tumor was thought of.

At an early stage of the operation when the muscles were being taken away from the lateral surfaces of the spinous processes and the vertebral arches, an extraordinarily profuse hemorrhage set in. It could not be arrested even after prolonged compression. Every vessel had to be caught separately and ligated. This was the only instance in my numerous operations in which I had to cope with such a complication. The greatest loss of blood was from an osteo-periosteal vessel in the arch of a vertebra close to its attachment to the vertebral body. While drilling the arch of the 7th dorsal vertebra, similar profuse hemorrhage set in. Since the operation had at that time lasted over two hours and the patient was in a collapsed condition on account of the great loss of blood, the divided muscles were united with four buried sutures and the wound of the skin closed over it. It required twenty-five days of rest after this operation, before the patient recuperated sufficiently so that it could be completed. The wound had healed and it was cut open again, the cicatrized muscles were detached from the spinous processes and arches, during which the bleeding was considerably less than the first time. Strong hemorrhage resulted during the detachment of the muscles from the arches and it could not be controlled by compression with tampons dipped in a solution of adrenalin. A few profusely squirting arteries of the bone were controlled by hammering them with *Passow's* chisel. The bleeding then ceased. The 5th, 6th, and 7th arches of the thoracic vertebræ were removed in the usual manner, and the dura lay freely exposed. The loss of blood was so great that it was impossible to continue the operation. The extremely accelerated pulse was only barely perceptible in the carotid. The dura was normal in appearance. It showed weak, distinct pulsations. Probing between dura and bone upward and downward to a distance of about 18 cm. disclosed no obstruction. The dura was now closed with interrupted sutures and healing progressed very favorably, so that the patient could leave for home after three and a half weeks. She died seven weeks later, however, from bilateral pyelonephritis and exhaustion. After opening the dura the post-mortem examination showed at the level of the 5th and 6th dorsal vertebra, on the left side of the pia, a convoluted mass of very dilated, dark-blue vessels. The vessels of the pia surrounding this angioma (which was 25 mm. in length) were also dilated and very tortuous.

Tumors of the Spinal Membranes

Diagnosis

Résumé of Symptoms

All intravertebral neoplasmata, be they situated extra- or intra-durally, produce, by their gradual progressive compression, clinical manifestations from involvement of the spinal nerve roots or the spinal cord itself. Occasionally these are associated with symptoms referrible to the vertebral column.

While these three groups of symptoms, described and classified by *Ludwig Bruns,*[1] are not characteristic and specific, the study of their development in the course of the disease renders a correct recognition of the malady in most instances possible.

Careful study of the development of the symptoms is therefore of the utmost importance. Of course, we will be compelled to depend mainly upon the statements of the patients, because individuals afflicted with spinal trouble are, as a rule, not under observation for any length of time, except in severe (fortunately rare) cases.

The following manifestations are found in instances of irritation and compression of the spinal nerve roots and their points of origin. Pain, hyperæsthesias and anæsthesias in the course of distribution of the respective roots (radicular), muscular spasms and spasticitis, finally limited (also radicular) flaccid paralyses of muscles and muscular atrophies which are, as a rule, associated with disturbances of the electrical irritability of the muscles involved. Disappearance of certain reflexes may also be mentioned here. The beginning of the trouble is characterized by symptoms of irritation, the further course by annihilation of conductivity. All those manifestations which frequently develop in part with fluctuating intensity may be brought about by an involvement of the nerve roots or their spinal segments; they are therefore

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[1] *L. Bruns,* Die Geschwülste des Nervensystems. 2. Auflage. Berlin, 1908.

designated as root- or segment-symptoms. They usually occur on one side and, since they correspond to the site of the neoplasm, they are of utmost importance in level diagnosis, as we shall see later on.

The second group of symptoms is represented by the manifestations resulting from compression of the cord. If the tumor develops from the side, as is usually the case, the corresponding half of the spinal cord will suffer in characteristic cases a greater or less complete interruption of conduction which is known as *Brown-Séquard's* unilateral lesion. In some cases this important symptom-complex is absent, and the compression of the cord by the tumor leads, without this preliminary stage, directly to a spinal paralysis corresponding to the transverse section of the area involved. In cases of complete interruption of conduction all regions, the innervation of which is situated below that transverse section, become paralyzed. This severe disturbance is, therefore, only applicable in special cases in diagnosing the level at which the tumor is suspected. These cases are usually characterized by total motor and sensory paraplegia with involvement of the bladder and rectum and frequently also with trophic disturbances.

After these preliminary remarks a brief description of the clinical manifestations may prove of value.

L. Bruns, in his monograph above referred to, has distinctly divided the

Root Symptoms

from those resulting from an interruption of conduction of the spinal cord. It is to be remembered, however, that at a time when we find certain segmental manifestations (paralyses and anæsthesias) as a result of compression, the conduction of the cord from below upward in the corresponding region will be found more or less interrupted. The clinical differences in these cases are therefore indistinct. On the other hand,

Symptoms of Irritation of the Spinal Nerve Roots

are usually the first manifestations, and their presence is demonstrated before any manifestations from pressure set in. If they are of slight degree, the sensory roots will occasion **paraesthesias** in the form of formications, sense of numbness, and a sensation as if the part would "go to sleep." These manifestations may precede all other symptoms and again they may disappear for long periods and occasionally set in only when the patient attempts movements.

After the paræsthesias, the earliest and at the same time most annoying clinical manifestation in cases of severer irritation is **pain.** It may, however, be absent. Any one with experience will corroborate the statement that this most subjective of all symptoms is very variable and has only a limited application in diagnosis. As in any other part of the body, especially in typical neuralgias like the trigeminus for instance, the pains may radiate to contiguous and occasionally distant parts. This is observed early in the history of neoplasmata of the spinal cord. Pains are of value as a diagnostic phenomenon when they are distinctly localized to a certain area and when they do not change position. They are especially characteristic in instances of limitation to particular nerve roots. Since intradural neoplasmata are, as a rule, situated laterally; i.e., to the side and posterior to the cord, pains may remain localized to one side and continue in that situation throughout the disease. In other cases again, especially where the tumor originates from the posterior surface of the meninges, the pains will be bilateral. I have seen it embrace both regions of the shoulders and be perceived by the patient as a distressing "girdle sensation" around the entire thorax.

The pains are occasionally of greatest severity and rob the patient of his sleep. They are sometimes elicited or aggravated when he attempts to move, and they are made to disappear when at rest, so that in certain instances they may be looked upon as manifestations of fatigue. Certain positions and sudden changes of position may invite the pains, and this is also observed during strong muscular tension, as in coughing, sneezing, pressing and laughing. Some patients ascribe their occurrence to a certain injury, an overexertion or an exposure to cold. According to the seat of the trouble the patient will complain of gnawing or tearing or, perhaps, radiating pains in the arms or lower extremities, or of a girdle sensation of the thorax, so that in the absence of other morbid manifestations they are being treated for intercostal neuralgia, rheumatism, or sciatica. These diagnoses are upheld with greater certainty where the pains, which were severe in the beginning, become milder later on and may entirely disappear for a number of weeks in succession. It is a known fact that intervals during which the patient is entirely free from pain and periods of total well-being are observed at times. I recall a case in which the initial pains assumed the form of angina-pectoris; in other instances again they were perceived as periodic gastralgia or gall-stone colic.

Of greater diagnostic value than the pains are **hyperaesthesias of certain regions of the skin.** These are, of course, less frequent and are caused by an irritation of the spinal roots which innervate the respective areas. Their extent does not correspond to the particular course of the peripheral nerve, but to the areas supplied by the root in question (see Figs. 164-167, pp. 985-988). The hyperæsthetic zone is occasionally found exactly above the region of spontaneous pain.

While manifestations of irritation of the sensory roots occur early and are, as a rule, marked, they are less frequently observed in the motor parts. Irritation of the anterior roots of the spinal cord are characterized by spasmodic contractions of a tonic or clonic type limited to certain regions supplied by particular roots. These manifestations are extremely rare, however, and of little value for diagnostic purposes. It must be constantly kept in mind, however, that muscular tensions and twitchings may also be brought about in a reflex manner from irritation of the sensory roots.

Irritation of the sensory roots is followed by compression from the growing tumor. This again is followed later on by

Anœsthesias and Paralyses

which from a diagnostic point of view offer, from their objective nature, a more certain basis for diagnosis than do pains. According to *Sherrington's* examinations, conduction of three adjacent roots must be destroyed before real objective manifestations are demonstrable. This is due to the many nerve anastomoses. This is true for motor as well as sensory regions. Anæsthesia of certain regions of the skin corresponding to particular nerve roots is not of frequent occurrence. Paralyses resulting from lesions of the anterior roots are associated with atrophy of the muscles and the reaction of degeneration. Disturbances of nutrition and of the electric irritability of the muscles require extensive lesions of the roots and are therefore late manifestations. *Oppenheim* has pointed out that in cases of extramedullary neoplasm there exists a striking disproportion between the degree of atrophy and the slight changes in electric irritability.

It should be emphasized once more that these manifestations will appear when the disease affects certain roots which will give rise to pains and anæsthesias, spasms, and tensions of the muscles and, finally, trophic and electric disturbances. By far more distinct is the occurrence of disturbances of motility and sensibility in cases where the compressing neoplasm occasions

Interruption of Conduction in the Cord Itself

For in such cases the disturbances are reflected to all tracts of conduction corresponding to the compressed section of the cord.

In some cases of compression of the posterior columns (see Observation XVII, 2) ataxic gait was observed. This ataxia is, of course, in most instances almost completely overshadowed by the existing paralysis, and after successful extirpation of the tumor when the paralysis recedes, it becomes distinctly manifest.

Since, as stated above, neoplasmata of the spinal meninges originate from one side, the cord will naturally be compressed on that side. The result of such compression, if the tumor be seated above the lumbar section of the cord, will be the occurrence of

Brown-Séquard's Unilateral Lesion,

the disturbances of which are as follows:

There is a motor paralysis and a disturbance of the muscular sense (sense of position) on the side corresponding to the tumor in all regions the innervation of which leads to the compressing focus. The paralysis is of a spastic character with exaggerated tendon reflexes. Occasionally very annoying and extremely painful spastic manifestations are observed in the extremities, and if the neoplasm be seated in a certain position, there will be a boardlike tension of the abdominal muscles. The spastic paralysis may persist for a long time and occasionally it may become flaccid with disappearance of the tendon reflexes. On the other side of the tumor corresponding to the same area of distribution, there exists a diminution and more rarely total abolition of the senses of pain and temperature and also of the tactile sense of the skin. These principal manifestations are accompanied by disturbances of innervation of the skin, i.e., at the level of the tumor a hyperæsthetic zone will be found (on the side corresponding to the tumor), and close below this hyperæsthetic region, a narrow zone of complete anæsthesia is occasionally demonstrable.

The slower the growth of the tumor and the pressure exercised on the spinal cord, the slower will be the development of the unilateral lesion. In this respect, however, the most varied differences are observed. Soft, rapidly growing tumors causing œdema or, perhaps, hemorrhages into the substance of the cord may, under the beginning root-symptoms which in rare instances may be absent, lead to a rapid, more or less complete transverse interruption. *Brown-Séquard's* symptom-complex does, therefore, not necessarily develop in extramedullary newformations. This also depends upon whether the cord is affected on one side only by the growing neoplasm or in its entire transverse section, and also whether the compression, which in the beginning was unilateral, had rapidly involved the other side sympathetically.

Oppenheim has pointed out that a tumor affecting the middle portion of the cord may cause distinct manifestations referrible to the posterior columns and thereby render a diagnosis very difficult.

Transverse Lesion

Compression finally causes the unilateral lesion to progress to a more or less complete paraplegia in which the motor and sensory disturbances extend from the lower portions of the body to the level of the tumor. In these cases the disturbances of motility of the respective regions develop more quickly and lead to complete paralysis, while the sensory sphere still shows isolated regions that functionate, and also that the anæsthesia does not extend so high up. The electric irritability of the affected muscles is usually normal. Even in progressive stages of the disease the symptoms found in the paraplegic stage consist of spastic paralyses with disturbances of muscular sense and exaggerated tendon reflexes. In some cases the slightest touch caused muscular spasms of the extremities of such severity that the joints could not be moved even with great force. In one instance of tumor of the cervical cord this condition and the continual flying up of the extremities on the slightest provocation were so marked and painful, that both lower extremities had to be immobilized in splints. If the conduction of the cord is completely interrupted, the tendon phenomena may also disappear and the paralysis finally becomes of a flaccid type.

Unspeakable tortures may be caused by *paralysis of the abdominal muscles.* The abdomen in such cases is continually distended, and extremely unpleasant eructations and even vomiting occurs on account of involvement of the musculature of the stomach and intestines. In the case of a man fifty years of age who sustained an injury which resulted in a laceration of the interarticular disc and a luxation of the 6th and 7th thoracic vertebræ dividing the cord transversely, the stomach and bowels were so enormously distended that, as shown by the autopsy, the serosa was torn in many places longitudinally, and a beginning peritonitis was found which caused the death of the patient seven days after the injury.

The *skin reflexes* are exaggerated, at least in the beginning of the trouble, and this exaggeration may give rise to the strongest clonic twitchings of the extremities. To this are added pathologic reflexes such as the *Babinski* and *Oppenheim* manifestations as well as the *Bechterew-Mendel* reflex. The reflexes of the skin disappear in the later stages of transverse interruption.

With increasing compression of the spinal cord the *functions of the bladder and rectum* and also of the *sexual sphere* become sympathetically affected. In the case of a man the first manifestation consisted of an incontinence of the bladder when the patient was coughing, a condition which is of frequent occurrence in females under normal conditions. The same patient, who was very observant, described a sort of weakness of the sphincter ani which, however, was not discovered by the palpating finger. I have also seen paræsthesia of the urethra in connection with these cases.

Of *trophic disturbances* the following were observed: Dryness, scaling, œdema, formation of blebs and ulcers of the skin, decubitus and finally cystitis and pyelonephritis. Later on in the disease the joints may also show trophic disturbances. I have once observed excessive sweat excretion on the affected side of the body.

Manifestations from the Vertebral Column

As previously stated, there is a third group of symptoms—the result of participation of the spinal column. Even in intradural neoplasmata certain vertebræ may become sensitive or painful on carrying weight, on pressure, to percussion and concussions from the head and finally at such movements as coughing and sneezing. The application of a hot sponge has in most instances yielded at my hands negative results. Pain corresponding to the seat of the neoplasm, corroborated by the other manifestations, is an important symptom. In some cases pressure on certain spinous processes will cause radiating pains. Percussion with the finger and hammer does not only elicit the seat of the pain, but may also show differences in the percussion sound *(Oppenheim),* a symptom which, of course, must be applied in diagnosis with greatest caution.

As a result of pains and secondary muscular tensions, disturbances in the mobility of the vertebral column may attain a high degree, especially in neoplasmata of the cervical cord. Secondary deformities may also result. I have seen a case in which the head was so strongly bent on the thorax that the chin rested against the sternum and could not be moved from it, while the movements of rotation were free. X-ray examinations yield good results only in cases in which the neoplasm springs from the bone or from the periosteum (enchondroma or osteoma). Tumors that have undergone calcification may also cast a shadow. According to *Leyden* and *Grunmach,* trophic disturbances, such as halisteresis of the vertebræ for instance, may also be caused by diseases of the spinal cord itself.

Résumé of the Diagnosis

To arrive at a diagnosis of a space-restricting process in the vertebral canal, the clinical picture must have attained a certain rotundity. It is justified in typical cases when the manifestations of irritation of the roots are associated with symptoms of compression of the spinal cord, especially when the latter displays a more or less decided character of *Brown-Séquard's* lesion, and when found at the level corresponding to the lesions of the roots. Interruption of conduction may, of course, be complete from the very beginning *(Stertz).* In rare cases pains consequent to irritation of the roots were also absent. This is readily explained when the tumor is seated in the anterior half of the cord or posteriorly in the median line and does not come in contact with the regions of the roots. After a time the pains completely disappear when the increasing compression totally interrupts the conduction centralward *(F. Schultze*[1]*).* At other times again the occasional girdle sensations complained of by the patient below the seat of the neoplasm, evidently resulting from irritation of intraspinal tracts, must not lead one, from this symptom alone, to make a diagnosis of another neoplasm situated below the first.

Duration and Course

The disease is usually extremely chronic. It may be limited to these symptoms of irritation (pains) for years before other symptoms occur. Benign neoplasmata, as for instance the psammoma of Observation XIII, 1, p. 997, is, on account of its slow growth, especially characteristic in this respect. Sarcomata, of course, lead to a more rapid development of the manifestations of transverse lesion. In isolated cases the entire symptom-complexus developed in a very short time. It must finally be stated that the symptoms do not always increase in every case alike, and that periods of latency or even improvement may be observed.

Etiology

In a number of our cases the patients ascribed their disease to injury, for example: slipping and falling on the back, or a sudden jar on the vertebral column. In most instances, however, the anamnesis will disclose that certain disturbances have existed before the accident and that the latter had caused a considerable aggravation of the symptoms. It may be possible that hemorrhages into the tumor or œdematous swellings have occasioned an increase of pressure.

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[1] *Friedrich Schultze,* Neubildungen der Rückenmarkshäute und des Rückenmarkes. "Deutsche Klinik." Berlin, Wien, 1905, p. 954 ff.

It can hardly be my task to enter here into a discussion of the extremely difficult *differential diagnosis between intradural and intramedullary neoplasmata.* I have frequently heard *H. Oppenheim* discuss this question at consultations, and have noted the careful manner in which this experienced diagnostician proceeds, and I would, therefore, not attempt to undertake this difficult task at this place, where only a general résumé should be given.

Diagnosis of the Level of the Tumor

The manifestations thus far studied have taught us that space-restricting processes are, as a rule, limited to the vertebral canal. If the comparison be permitted, I should like to compare the manifestations of general cerebral compression in space-restricting processes within the skull with those under discussion. Just as the study of the focal manifestations of the brain are of utmost importance in ascertaining the particular location of the etiologic factor causing them, the symptoms referrible to the spinal cord must be studied with extreme care in order to arrive at a correct diagnosis of the level of the neoplasm in this organ. This is accomplished with greater ease in the cord than in the brain. In the former the peculiar arrangement of individual root regions in segments makes a diagnosis possible, while in the brain an enormous number of fibre-tracts course and penetrate each other in every direction, so that until up to the present day only a small number of these are known to us, despite the progress made in this particular field.

The earlier the operation is undertaken for the relief of the disease, the less severe it will be and the more favorable the outlook for complete recovery. It is, therefore, of utmost importance that the diagnostician should study all symptoms individually and collectively with extreme care in order to ascertain the level at which the neoplasm is suspected. These are spoken of as

Root and Segment Symptoms

on account of their being localized to the territory supplied by the roots or segments and distribution of the nerves upon which the abnormal pressure by the tumor is exerted.

The most important of root-symptoms are the objective manifestations in the form of paralyses and anæsthesias and above all, the atrophic paralyses of the muscles. Pains, on the other hand, are not always an important diagnostic phenomenon and, as stated above, should be studied in conjunction with the other symptoms. If strictly circumscribed to a particular area, they may be of great importance. The *pains* and more frequently *hyperæsthetic regions of the skin* are usually found at the upper border of the tumor. Both are the result of direct pressure by the tumor on the sensory root fibres. If the tumor extends upward, new roots will become involved and the pains will therefore correspond to the region supplied by the highest segment. Greater compression will be exercised by the tumor upon the roots and cord below this region; the result will be interrupted conduction. The irritation is, therefore, not transferred to the deeply situated root regions of the cerebral cortex—hence the patient is not conscious of their existence. On the contrary, interrupted conduction occasionally leads to the *formation of anæsthetic zones* which are naturally situated below the region of pain and hyperæsthesia.

H. Oppenheim[1] has recently reported a case in which in place of hyperæsthesia there existed a *hyperreflexia* in the upper region of the abdomen and hypochondrium. During the operation it was shown that the 8th root passed the upper border of the tumor which was irritated by it. The hyperreflexia was in this instance of equal diagnostic importance with reference to the diagnosis of the level of the morbid condition as is the hyperæsthesia under similar circumstances.

The

Functions of the Roots and their Corresponding Segments

are at the present time pretty well known with reference to their relation to the various regions of the skin, to the muscles and the reflexes. With reference to the first, it should especially be emphasized that the sensory nerve-end fibres always supply a certain area corresponding to the respective root of the spinal

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[1] "Berlin. klin. Wochensch.," 1909, No. 26.

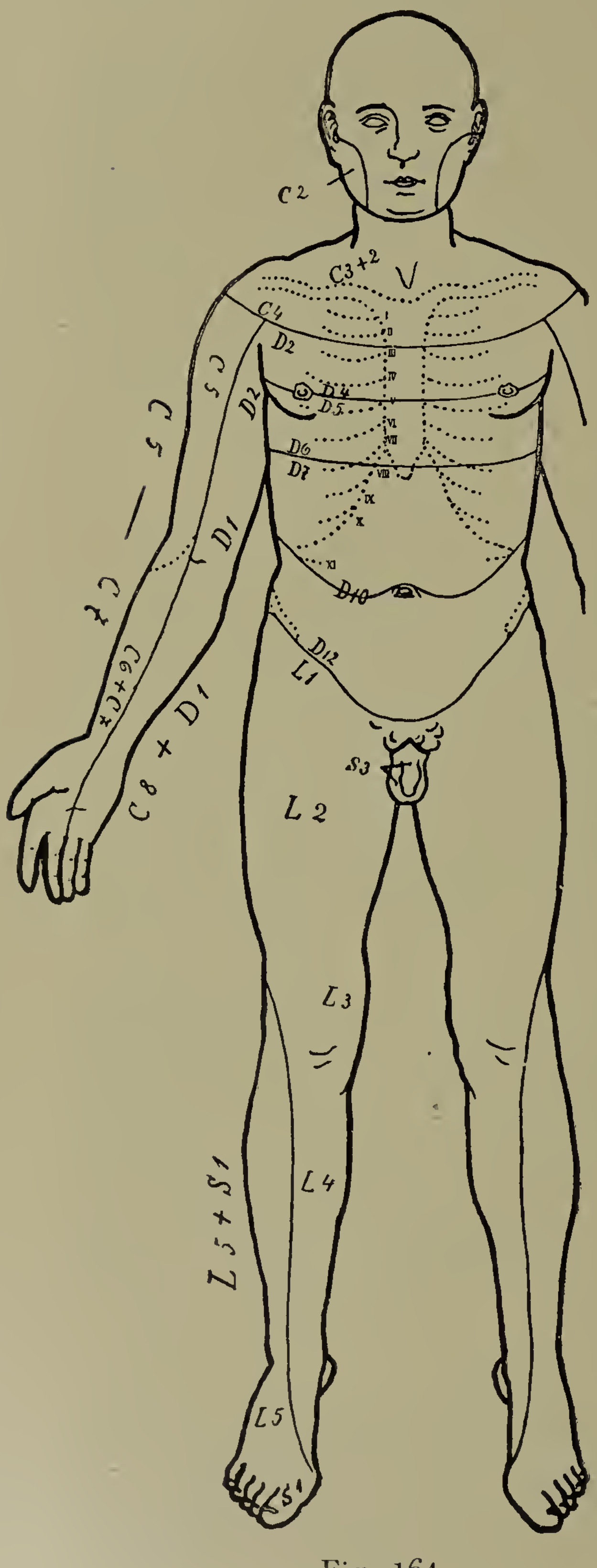


Fig. 164

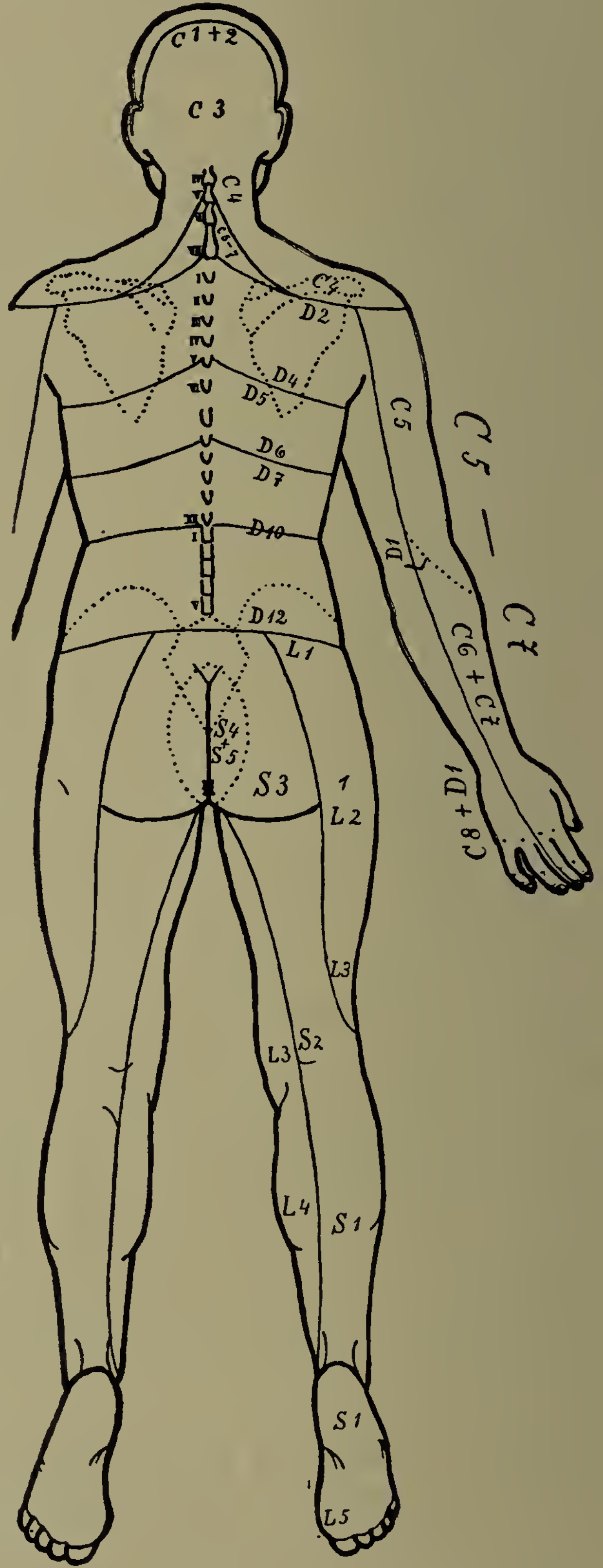


Fig. 165

Seiffer's Scheme of Segment Diagnosis of Sensory Disturbances.

cord *(root-field* or *radicular zone),* irrespective of its course in the nerve plexus and further ramifications. As has been stated, a number of root regions are usually associated with one another (by means of extensive anastomoses) in the innervation of a particular region of the skin. According to *Sherrington's* experiments on monkeys, three, and according to *L. Bruns'* clinical experiences, occasionally five segments anastomose with one another. In *Seiffer's* scheme (see Figs. 164, 165, p. 986) the middle of the three spinal roots supplying a given area of the skin is pointed out. Complete anæsthesia can therefore only occur when all three roots have lost their conductivity. Even when two are destroyed and only one is functionating, sensation is retained.

The Sensory Root-Fields

are represented in Figs. 166 and 167 by *R. Bing* in such a manner that the zone in question is situated to both sides of the line carrying the number of the segment. The great difference between the root-fields and the regions of innervation by the peripheral nerves is distinctly shown in the figure by comparing both halves of the body (areæ radiculares, areæ nervorum).

In a case of intradural neoplasm at the level of the arch of the 7th cervical vertebra down to the arch of the 2d thoracic, we were able to point out that the patient perceived contacts with the brush in a narrow strip exactly in the median line from the thorax to the umbilicus, while the anæsthetic zone corresponded to the seat of the neoplasm—upward, almost to the 2d rib.

If all facts with reference to segmental diagnosis be taken into consideration, that segment is to be looked upon as the one uppermost affected, the region of which (sensory scheme and with reference to *Sherrington's* experiments) corresponds to the upper border of the sensory disturbance and the paralysis.

With reference to localization of pain, *Sherrington's* law should also be taken into consideration, and the highest of the three roots which participate in the innervation of the respective area of the skin must be located. A great number of clinical experiences, as we shall see later on, have shown that the irritation on the roots is exercised at the level of their departure from the cord and not on their inner, intradural course.

With reference to the

Segment Innervation of the Muscles

the following diagrams of segment diagnosis of motor paralyses by *E. Villiger* furnish the quickest information. Through the

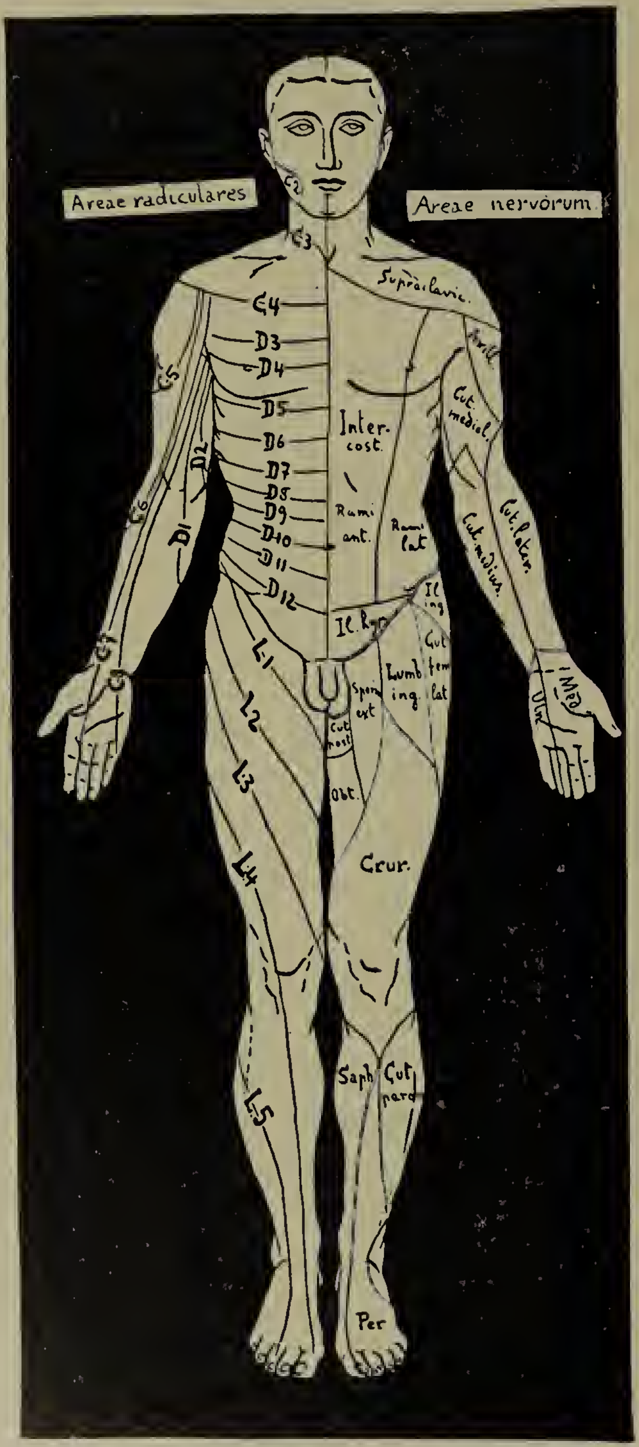


Fig. 166

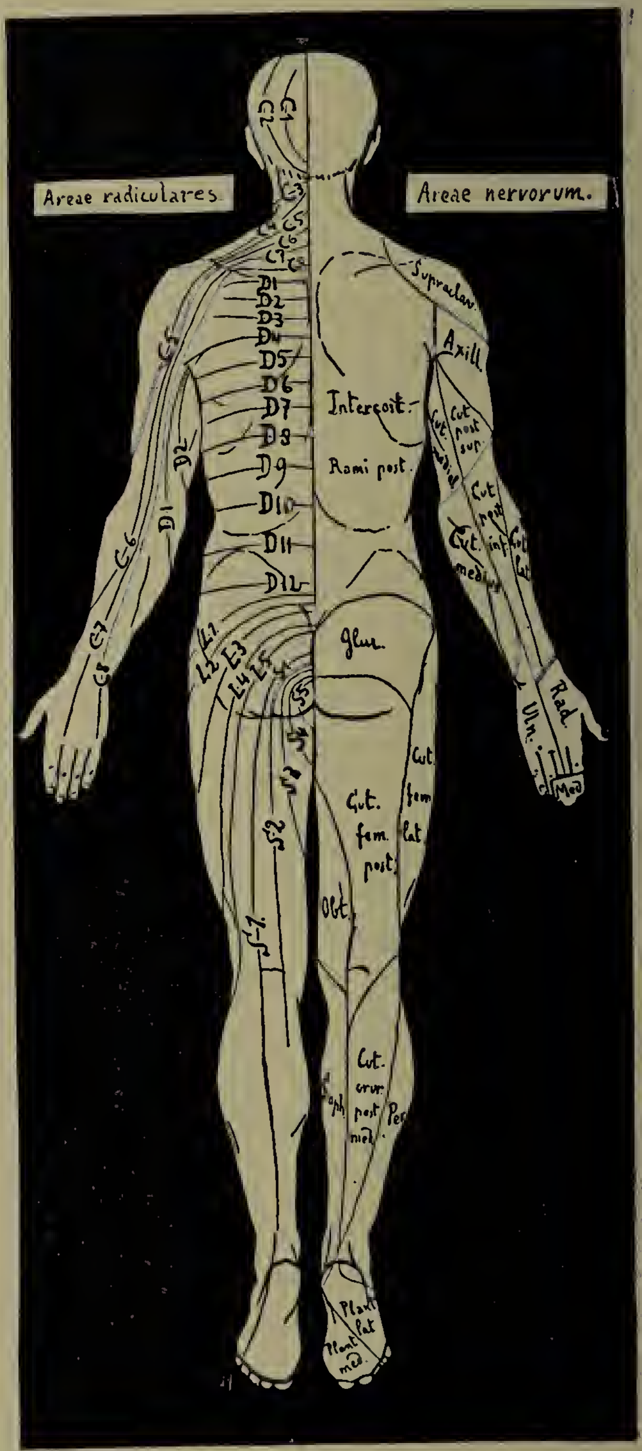
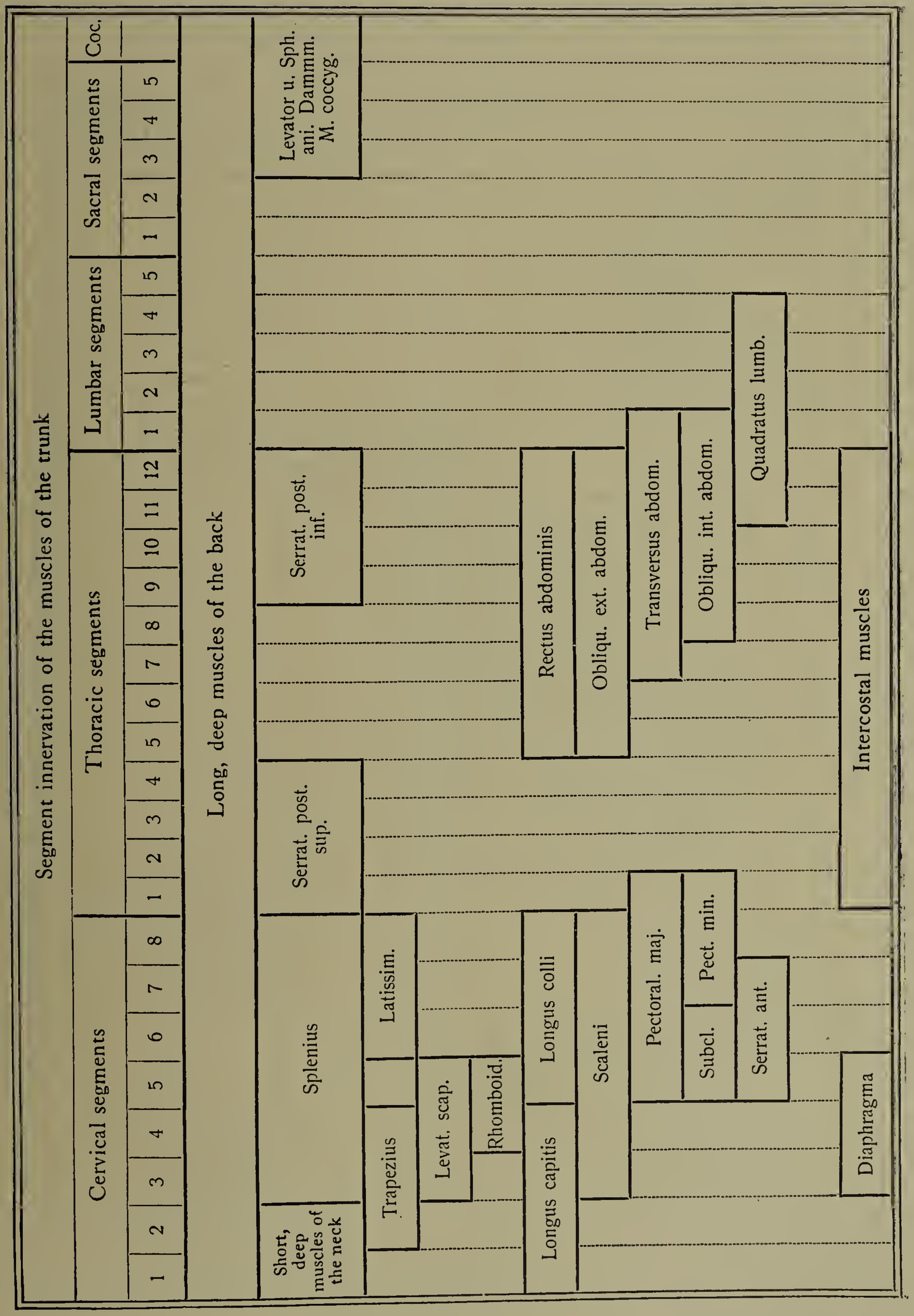
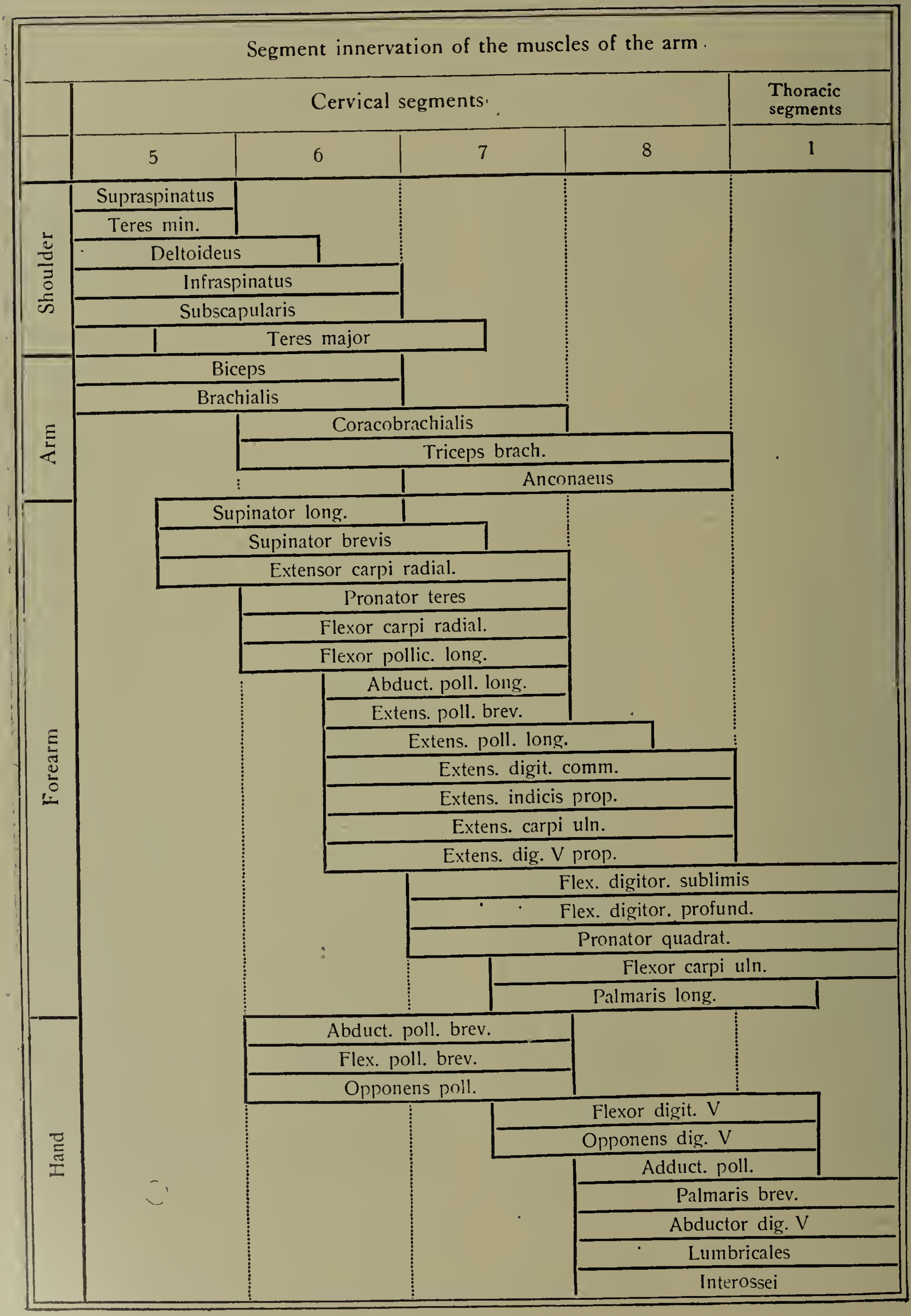


Fig. 167

R. Bing's Schemes of Segmental Diagnosis of Sensory Disturbances.

On the left the sensory root-fields (areæ radiculares).
On the right the skin areas of the individual nerve trunks (areæ nervorum).


Segment innervation of the muscles of the trunk
Cervical segments
1
2
3
4
5
6
7
8
Thoracic segments
1
2
3
4
5
6
7
8
9
10
11
12
Lumbar segments
1
2
3
4
5
Sacral segments
1
2
3
4
5
Coc.
Long, deep muscles of the back
Short, deep muscles of the neck
Splenius
Serrat. post. sup.
Serrat. post. inf.
Levator u. Sph. ani. Dammm. M. coccyg.
Trapezius
Latissim.
Levat. scap.
Rhomboid.
Longus capitis
Longus colli
Scaleni
Rectus abdominis
Obliqu. ext. abdom.
Pectoral. maj.
Subcl.
Pect. min.
Transversus abdom.
Obliqu. int. abdom.
Serrat. ant.
Quadratus lumb.
Intercostal muscles
Diaphragma


Segment innervation of the muscles of the arm.
Cervical segments
Thoracic segments
5
6
7
8
1
Shoulder
Arm
Forearm
Hand
Supraspinatus
Teres min.
Deltoideus
Infraspinatus
Subscapularis
Teres major
Biceps
Brachialis
Coracobrachialis
Triceps brach.
Anconaeus
Supinator long.
Supinator brevis
Extensor carpi radial.
Pronator teres
Flexor carpi radial.
Flexor pollic. long.
Abduct. poll. long.
Extens. poll. brev.
Extens. poll. long.
Extens. digit. comm.
Extens. indicis prop.
Extens. carpi uln.
Extens. dig. V prop.
Flex. digitor. sublimis
Flex. digitor. profund.
Pronator quadrat.
Flexor carpi uln.
Palmaris long.
Abduct. poll. brev.
Flex. poll. brev.
Opponens poll.
Flexor digit. V
Opponens dig. V
Adduct. poll.
Palmaris brev.
Abductor dig. V
Lumbricales
Interossei

Segment innervation of the muscles of the lower extremity

<table>
<tr><th></th><th>Th_{12}</th><th>L_1</th><th>L_2</th><th>L_3</th><th>L_4</th><th>L_5</th><th>S_1</th><th>S_2</th></tr>
<tr><td rowspan="11">Hip</td><td colspan="5">Ileopsoas</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">Tensor fasciae</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">Glutaeus medius</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">Glutaeus minim.</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">Quadratus femoris</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">Gemellus inferior</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="4">Gemellus super.</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="4">Glutaeus maxim.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="3">Obturator intern.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Pyriformis</td></tr>
<tr><td rowspan="13">Thigh</td><td></td><td></td><td colspan="2">Sartorius</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="2">Pectineus</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="2">Adduct. long.</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="3">Quadriceps</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="3">Gracilis</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="3">Adductor brevis</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Obturator ext.</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Adduct. magn.</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Adduct. minim.</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Articularis gen.</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">Semitendinosus</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">Semimembranosus</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="4">Biceps femoris</td></tr>
<tr><td rowspan="15">Leg</td><td></td><td></td><td></td><td></td><td colspan="2">Tibialis ant.</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">Extensor halluc. long.</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">Popliteus</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">Plantaris</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">Extensor digit. long.</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="4">Soleus</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="4">Gastrocnemius</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2">Peroneus longus</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2">Peroneus brevis</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="3">Tibialis postic.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="3">Flexor dig. long.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="3">Flexor halluc. long.</td></tr>
<tr><td rowspan="14">Foot</td><td></td><td></td><td></td><td></td><td colspan="3">Extensor halluc. brev.</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">Extensor digit. brevis</td><td></td></tr>
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<tr><td></td><td></td><td></td><td></td><td></td><td colspan="3">Flex. halluc. brev.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="3">Lumbricales</td></tr>
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<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Abduct. dig. V</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Flexor dig. V br.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Opponens dig. V</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Quadrat. plant.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Interossei</td></tr>
</table>

kind permission of the author they are herewith reproduced from *Robert Bing's* "Compendium of Regional Diagnosis in Affections of the Brain and Spinal Cord."[1]

Most muscles, especially those the segmental supply of which is well known, and those exactly corresponding to the sensory root regions, are divided mainly into three segments. The middle of these three segments is to be looked upon as the main segment of the corresponding muscle. A certain muscle will, therefore, become totally paralyzed and will show atrophy and disturbances of electric irritability when the conductivity of at least all three anterior roots innervating it is destroyed. One of these, that is still functionating, may prevent the occurrence of paralytic manifestations. It should be mentioned, however, that as a result of individual deviations and peculiarities, a displacement of certain groups of roots to an extent of a half or even a whole segment upward or below may be met with (*postfixed* and *prefixed types* of ***Patterson***).

The

*Disturbances in the Elicitation of **Reflexes***

are also of importance in segmental diagnosis, because interruption of the reflex arc causes the respective reflexes to disappear. The level at which the various reflex arcs are situated is shown in the table on page 991, which is also taken from *Robert Bing.*

It is to be remarked, however, that the skin reflexes may be abolished in cases of morbid foci situated above the reflex arc.

If certain reflexes be absent (for instance, absence of the abdominal reflex) on one side while the reflexes situated above and below it be present, this unilateral manifestation may be utilized in ascertaining the level of the diseased condition. Such a case was reported by *K. Mendel.*[2] On the other hand, the absence of the abdominal reflex on both sides cannot be used to advantage as a diagnostic phenomenon in this respect because it may be absent in cases of compression of the upper dorsal or even the cervical cord, even in those instances in which conduction is not completely abolished. Since *Oppen-*

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[1] Rebman Company, New York.

[2] "Berlin. klin. Wochenschr.," 1909, No. 50.

heim has especially pointed out that unilateral absence of the abdominal reflex is a constant manifestation in cerebral hemiplegia, we will not place sole reliance on this symptom alone, but will apply it in diagnosing level in conjunction with other symptoms.

	Tendon and Bone Reflexes	Skin Reflexes	How Elicited	Effect	Localization
1.	—	Scapular reflex	Irritation of skin over scapula	Contraction of muscles of shoulder-blade	C_5-D_1
2.	Biceps reflex	—	Blow on tendon of biceps	Flexion of forearm	C_5-C_6
3.	Triceps reflex	—	Blow on tendon of triceps	Extension of forearm	C_6-C_7
4.	Scapulo-humeral reflex	—	Blow on inferior inner angle of scapula	Adduction of arm	C_6-C_7
5.	Radius reflex	—	Blow on processus styloideus radii	Movement of supination	C_7-C_8
6.	—	Palmar reflex	Irritation of palm	Flexion of fingers	C_8-D_1
7.	—	Epigastric reflex	Stroking from nipple downward	Retraction of epigastrium	D_7-D_9
8.	—	Upper abdominal reflex	Stroking skin of upper abdomen	Retraction of abdomen	D_8-D_9
9.	—	Middle Abdominal reflex	Stroking skin of abdomen in middle and lower sections	Retraction of abdomen	D_{10}-D_{12}
10.	—	Lower Abdominal reflex			
11.	—	Cremaster reflex	Stroking adductor region of thigh	Retraction of testicle	L_1-L_2
12.	Patellar reflex	—	Blow on quadriceps tendon	Extension of leg	L_2-L_4
13.	— —	Gluteal reflex	Stroking of nates	Contraction of glutei	L_4-L_5
14.	Achilles reflex	—	Blow on Achilles tendon	Flexion of foot	S_1-S_2
15.	—	Plantar reflex	Stroking of sole of foot	Flexion of toes	S_1-S_2
16.	—	Anal reflex	Pricking of perineum	Contraction of sphincter ani externus	S_5

Ascertaining the Upper Level

In ascertaining the level of a neoplasm the finding of the upper limit is first to engage our attention. The morbid manifestations reach upward to an extent corresponding to the influence of the pathologic condition on the spinal cord and its roots. At the upper limit we have usually to deal with segment symptoms and the pains perceived here by the patient correspond to the uppermost spinal roots. The place of greatest compression of the cord is generally situated lower. According to my experiences differences in the position of the upper level may be found in extramedullary neoplasmata. Of course, this manifestation in these instances is only exceptionally found, but I have, nevertheless, seen it occur a number of times. In all of these cases an unusually large amount of liquor cerebro-spinalis had accumulated above the compressing neoplasm, and this collection of fluid had evidently exercised an action similar to that of the tumor itself. (See chapter on *Meningitis Serosa Chronica.*) In two cases the operation was performed two vertebral arches too high. In extreme fluctuations of the individual symptoms and in instances where the disturbances of sensibility change in intensity and in individual qualities at different times, and in those cases where there is a change in the position of the upper limit, we must think of the possibility of the existence of such an accumulation of liquor which may render a diagnosis of the level of the morbid condition difficult.

The cause for this fluctuation in the symptoms may in these cases be explained by changes in the pressure conditions of the accumulation of the pathologic fluid. Vascular neoplasmata with variable blood-supply and fluctuating serous infiltration depending upon it, exercising greater or less pressure upon the spinal cord, may act in a similar manner.

In summing up a level diagnosis, the symptoms that are in the foreground of the clinical picture and most constant, must be considered first.

Since the functions of particular nerve roots entirely coincide with those of the segments of the spinal cord corresponding with them, disturbances resulting from involvement of one or the other cannot clinically be separated. The origin of the roots from their respective segments lies only in the uppermost cervical section on about the same level as their exit from the intervertebral foramina. The farther we proceed downward, the longer will be found the course of the roots in the vertebral canal before they perforate the dura and reach the respective intervertebral foramen. For that reason we find the higher nerve roots always close to one or more segments and their roots situated below them. Fig. 168, p. 996, shows these relations in a schematic manner.

As may be surmised, these peculiar anatomic relations render a diagnosis difficult; they are, however, counterbalanced by the fact, learned from experience, that the roots running intradurally offer greater resistance to a compressing tumor, than the roots at their points of exit from the cord. We are, therefore, able to interpret the uppermost symptoms of paralysis and anæsthesia that point to an involvement of a certain root region in level diagnosis and to find the respective spinal segment even in those places where the nerve roots have to travel for quite a distance to the intervertebral foramina within the vertebral canal.

Relation of the Position of the Spinous Processes in the Spinal Segments

Locating the vertebral arch under which the neoplasm is situated is of prime importance in operating. To this end there is one guide that shows the surgeon the way to the depth, i.e., the spinous process. It is, therefore, of utmost importance to know the position of the bodies of the vertebræ, the arches and the spinous processes in relation to the respective segments of the spinal cord. Fig. 168 shows this relation as well as the position of the cervical and lumbar enlargements very distinctly.

With the exception of the upper cervical cord, the spinal segments and the points of exit of the nerve roots are always situated on a higher level than the vertebra of the same number. This difference becomes progressively greater the farther we proceed from above downward. The cord ends at the 2d lumbar vertebra, and in this situation, at the conus terminalis, the segments are very closely arranged. *Reid* has shown that individual variations are of quite frequent occurrence.

With reference to the palpable ends of the spinous processes they are approximately on a level with the bodies of the vertebræ only in the upper cervical and the lumbar portions of the spinal column. On the other hand, in the lower cervical and entire thoracic region, they are much lower than their respective bodies on account of their oblique direction. As stated above, in order to expose the desired vertebral arch the roof-tile fashion arrangement of the spinous processes, at its base, especially in the dorsal region, makes it necessary to snip off the spinous process next above it.

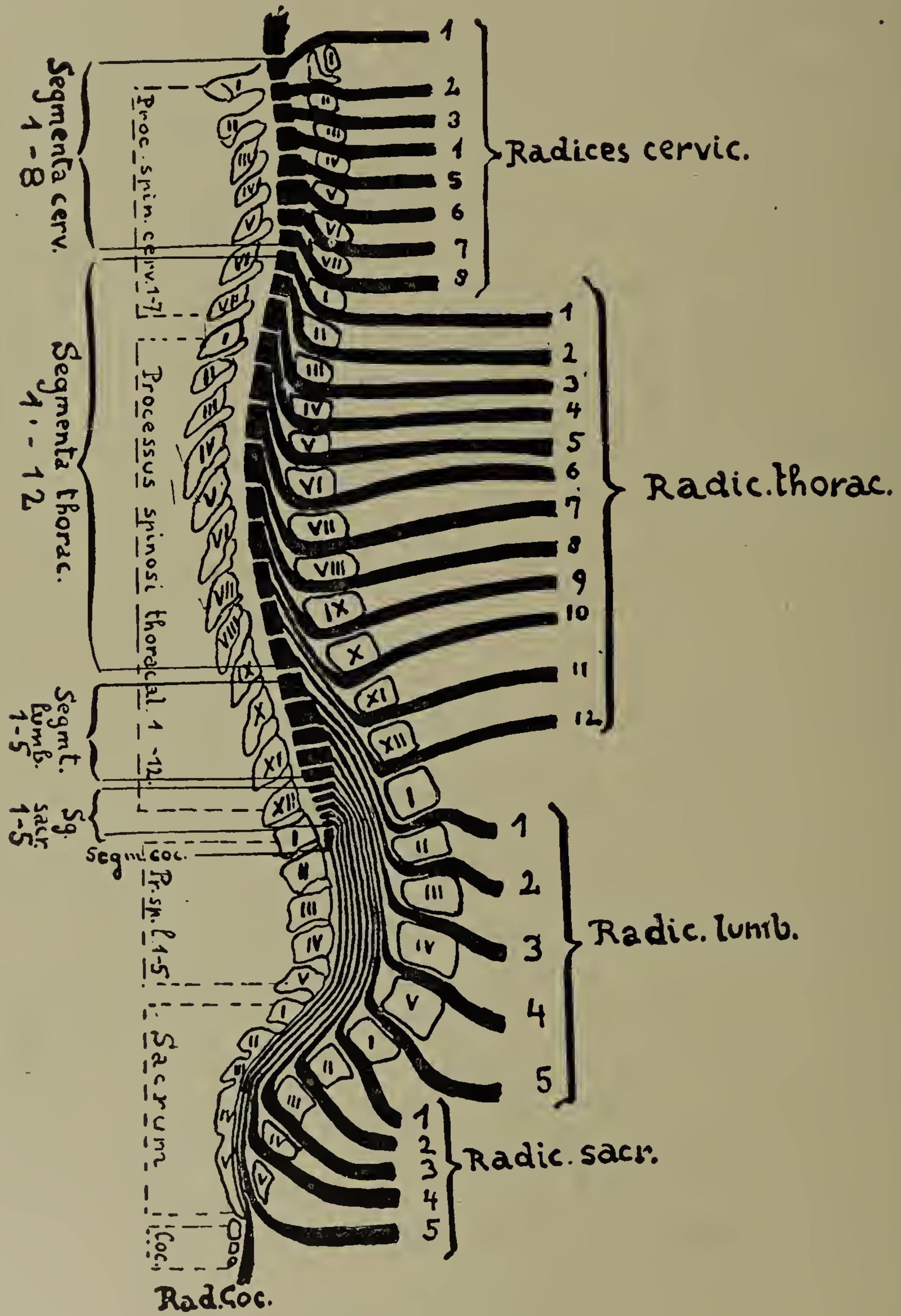

Fig. 168

Topographic Relations of the Spinal Segments to the Vertebral Bodies, Spinous Processes and Points of Exit of the Nerve Roots. (From *Robert Bing*, loc. cit.)

Cases in which the symptoms on the vertebral column are so distinct that they may be utilized in level diagnosis are rare. Sensitiveness to pressure of the spinous processes may be very misleading. In the case of a woman, sixty-six years of age, sensitiveness to pressure on the right side of the 6th thoracic vertebra was found at every examination, while the level diagnosis pointed to the 7th arch. At the operation an intradural tumor, measuring 35 mm., was found at the level of the 8th and 9th arches, while a very marked collection of liquor extended to the 6th arch above.

In a text-book on the subject these general remarks on diagnosis of the level of neoplasmata of the spinal cord should be followed by a description of the special morbid manifestations produced by the particular anatomic site of the neoplasm (cervical, thoracic, and lumbar cord). Since, however, as stated in the introduction of this work, this is not my aim, I prefer to point out the differences in the clinical manifestations by examples of personal observations.

I shall next describe a case of tumor in the middle of the dorsal cord in which *Brown-Séquard's* unilateral paralysis had developed. Later on I am giving striking examples of localization in the other section of the spinal cord.

OBSERVATION XIII, 1

Psammoma of the Dura Mater at the Level of the Arch of the Seventh Dorsal Vertebra. Operation, June 18, 1900. Cure Persisting in January, 1910.

Early in 1897, a slight trauma to the vertebral column was followed three months later by a weakness in the right knee of a woman, sixty-five years of age.

Soon after the onset of the disease, the patient had the sensation, when sewing, as if a mouse were running up quickly from the knee to the hip on the same side. Later on she perceived a burning sensation in the sole of the right foot while walking; within a few months this extended to the right lower extremity and to the hip. At that time (end of 1897, beginning of 1898) the patient was treated for sciatica of the right side. Later on the sense of burning extended to the left lower extremity and soon reached the pelvis. With a diagnosis of bilateral sciatica she was sent in July, 1898, to a watering-place, where she remained until August of the same year. To the pains of both lower extremities a sensation of tension and weakness around the hips and the thighs as well as a distinct girdle sensation ("as if a strongly compressing belt were tightened around me") was soon added. This girdle sensation extended from the lower part of the spine or the sacrum to the front over the iliac crests, and it was especially annoying in the region of the right hip at the time when the patient was admitted to the hospital.

The movements in the right lower extremity had very gradually diminished until about February, 1900; yet the patient was able to walk about when supported by a cane. Even in the summer of 1899 she was able to walk for an hour when, besides a cane she was supported by some one accompanying her. From February, 1900, however, the weakness in the right lower extremity rapidly increased, but even at that time the patient was occasionally able to leave the bed when supported by two persons who half-carried her about.

In the spring of 1900 a neurologist (*Dr. Böttiger,* of Altona) made a diagnosis of neoplasm of the spinal cord at the level of the 7th thoracic vertebra, and the patient was referred to my division on the 13th of June, of the same year.

When the patient was admitted to the hospital, a right-sided lateral lesion developed. The right lower extremity was almost completely paralyzed. The patient could be made to stand up only when two nurses held her under the right and left arm. Walking when supported in this manner showed that the left lower extremity was used quite well while the right was dragged after her in a paralytic manner. Testing the active mobility, with the patient in dorsal decubitus, the left lower extremity was found fairly normal, while in the right only the following movements were demonstrated: Weak movements of rotation at the hip; extremely weak dorsal flexion in the ankle-joint and in the joints of the toes, while plantar flexion was somewhat better; dorsal flexion was tolerably strong only in the big toe. The

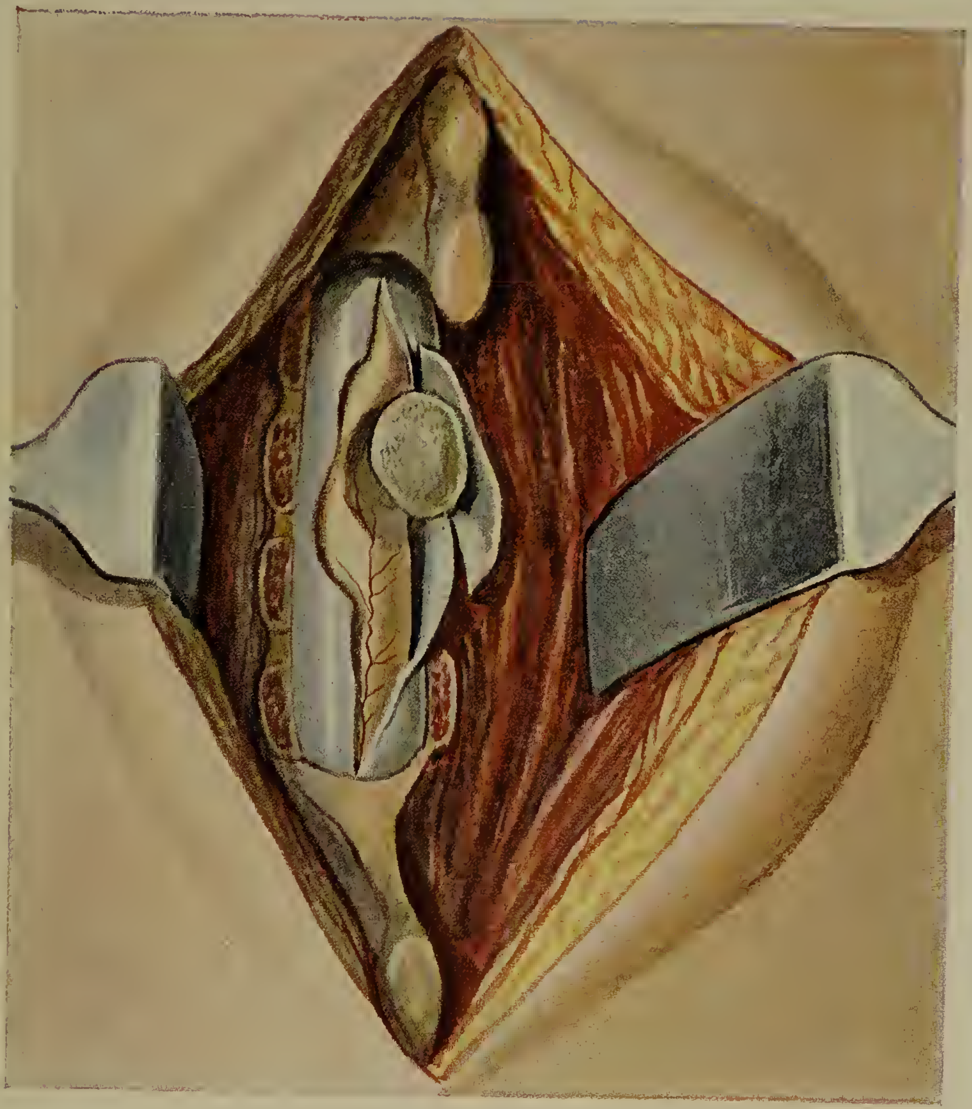

Fig. a.

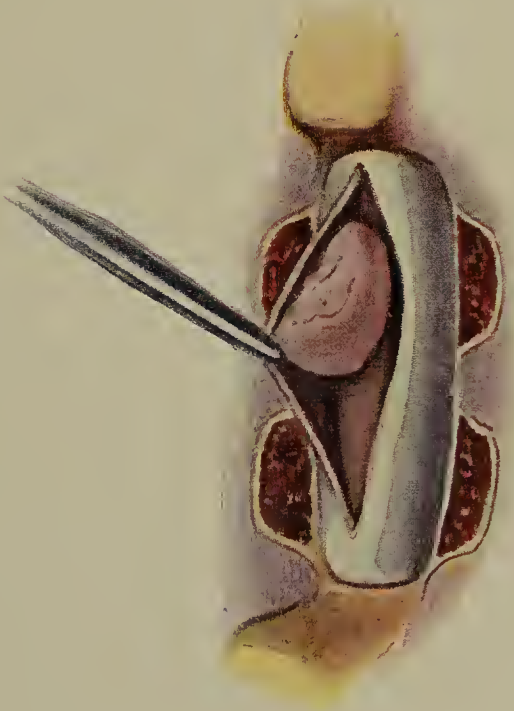

Fig. b.

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sense of position was found markedly reduced in the entire right lower extremity. The tendon reflexes were here in part highly exaggerated (Achilles' tendon reflex) and in part, according to *Dr. Böttiger's* findings, until recently, exaggerated, and at the admission to the hospital they were normal (patellar reflex).

Electric tests of the musculature showed that all muscles of both lower extremities responded to faradism in a normal manner.

With reference to the sensibility, an area, the size of the width of a hand, was found above and behind between the sacrum and the greater trochanter that was entirely anæsthetic to contacts with the brush, while it was hypalgesic to pricks with the needle. In no other part of the right lower extremity could sensory disturbances be demonstrated. Temperature sense was normal. On the left side the sense of pain was disturbed in the region of the entire lower extremity up to the ilium, and in the regions of the external genitals it was reduced. There were also disturbances in the temperature sense. The sense of touch, on the other hand, was entirely normal.

With reference to onset of the hypalgesia of the left (non-paralyzed) lower extremity, nothing could be elicited from the statements of the patient.

Marked burning pains were complained of in the entire left lower extremity which were mainly perceived by the patient when she stepped on the sole of the left foot. Contacts with the skin were also painful (paræsthesia). The same burning sensation was also perceived in the right lower extremity, but to a lesser degree; contacts with the skin here were not painful. These pains, however, were perceived in the right "hip," i.e., in the region of the crest of the ilium with greater intensity than in the left. The anamnesis disclosed that the pains existed on the right side for a longer period than on the left. When the patient was moving she perceived a sense of marked tension over the upper posterior border of the pelvis on the right side.

A striking atrophy of the right lower extremity did not exist. No decubitus or other disturbances of the skin (œdema, atrophy, vasomotor disturbances) could be found.

Disturbances of the bladder and rectum were only slight. The frequently occurring desire to urinate (hyperæsthia (?) of the mucosa of the bladder) had to be quickly satisfied, lest involuntary evacuation ensue *(imperative incontinence—Bruns).* With reference to the rectum there were constipation and involuntary expulsion of flatus.

On the 18th of June, 1900, the patient was anæsthetized with chloroform and the operation was performed. A longitudinal incision divided the skin and the soft parts underlying it down to the spinous processes to the extent of from the 6th to the 10th spinous process of the thoracic vertebra. I, at the time, still made use of the chisel with which I removed the arches of the 9th, 8th and 7th thoracic vertebræ in the above described manner and exposed the dura mater corresponding to them. The dura was very tense and did not pulsate. At the upper border of the opening of the bone immediately underneath the dura on the right side a hard object, about the size of the point of a finger and of the consistency of an enchondroma, was found. Next to it the dura was movable. In order to expose the tumor upward, the 6th arch had also to be removed, so that the vertebral canal lay now exposed to an extent of 75 mm. The tumor was felt to extend over the median line to the right, and its middle portion corresponded to the level of the arch of the 7th thoracic vertebra.

Above the tumor the dura pulsated distinctly. Above and below the neoplasm it was of a normal bluish color while the tumor was much whiter. The incision of the dura in the median line penetrated into the tumor which showed that it was in a small area united with the dura. During this step of the operation a large quantity of cerebro-spinal liquor drained away. After that, the cord distinctly receded above the tumor, thereby creating a hollow between the dura and the pia mater, while, below, the pia was raised at each inspiration, and also during expiration it remained distended. Distinct pulsation of the cord synchronous with the heart-beat was found above the tumor, while, below it, it was absent. The tumor (see Plate XLVIII, Fig. a[1]) could be easily detached and removed from the pia mater underneath it with the closed scissors. The pia was not injured.

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[1] Fig. b, Plate XLVIII, shows a fibrosarcoma of entirely similar form, which developed in a man, fifty-seven years of age, at the level of the arch of the 6th cervical vertebra, situated laterally and posteriorly, and it was united with the inner surface of the dura.

The dura, on the other hand, on account of it being united with the tumor, was excised to the entire extent of the neoplasm. After enucleation a distinct cavity, large enough to admit the introduction of the point of a finger, remained; it occupied a position posterior and to the right of the medulla spinalis. At the conclusion of the operation this concavity did not flatten. The tumor did not extend to the spinal roots.

Above and below where the dura had not been cut away but split in a longitudinal direction, both halves applied each other so neatly that their union by suture was unnecessary. At the lower angle of the wound a drain was introduced in such a manner that it reached to the chiselled portion of the vertebral canal. The musculature was now united immediately above the removed arches by six deep catgut sutures and the wound of the skin closed with silk. The length of the incision of the skin was 16 cm.

Tamponade and compression were entirely sufficient to arrest the bleeding, so that no ligations were necessary. The duration of the entire operation was forty-five minutes.

The tumor was the size of a hazelnut, semispherical; its consistency as hard as that of a stone and its surface granular. Its spherical surface corresponded to the cord and its flat portion to the dura mater. It was firmly united with the latter to a length of 12 mm. and a width of 5.5 mm. The length of the entire tumor, measured from above downward, was 17 mm., from right to left, 15 mm., and its greatest thickness, from the front backward, 11.5 mm. The dura was extirpated to a length of 40 mm. and a width of 17.5 mm.

For microscopic examination, the portion of the tumor immediately contiguous to the dura mater was made use of. It was very rich in cellular elements with numerous highly refractive concentrically arranged calcareous spheres which stained blue (hematoxylin). Outside of the entirely calcified spheres there were others, the peripheral parts of which were composed of flat cells that were not calcified but which enclosed a nucleus that had become calcareous. There were, finally, also spheres that showed no calcareous changes whatever and were composed of flat cells arranged concentrically. During the decalcification with acids, the spheres lost their refractive qualities under active development of gas ($CaCO_3$). Interstitial tissue contained many polymorphous connective tissue cells that lay apart without an intervening substance.

The course of healing of the wound was perfectly afebrile, and the urination was spontaneous. On the day after the operation the burning sensations in the lower extremities became milder, and three days later warm as well as cold were perceived on the left lower limb as lukewarm, and in the right they were felt correctly. Marked improvement in the motility of the toes (dorsal and plantar flexion) had already taken place. The drain was removed, and no more cerebro-spinal fluid was draining on the day following its removal.

One week after the operation the active movements of the right toes and right ankle-joint had still more improved, and the right knee could also be moved actively to a limited extent. The patellar reflexes were fairly normal on both sides. Distinct ankle-clonus could still be demonstrated on the right side. The hypalgesia in the left lower extremity was receding and the needle-point was correctly perceived in most places. One day later the improvement in the motility of the right knee and hip-joint was still greater. The right knee could be flexed to an angle of about one hundred and forty degrees. The quadriceps femoris began to be innervated voluntarily.

Eighteen days after the operation the mobility in the knee and hip showed still greater improvement; the knee could be brought actively to almost a right angle. Testing the sensibility of the left lower extremity, the point of the needle was everywhere perceived normal, while the sense of pain on the right was still somewhat finer than that of the left.

After twelve more days the function of the musculature of the quadriceps was still better, and the patient was able, when the knee was flexed to an angle of one hundred and fifty degrees and the thigh supported with the hand, to elevate the leg and to extend the knee; without support of the thigh this could not be done. Ankle-clonus was still very distinct on the right side and the patellar reflex somewhat weaker on the right than on the left. The patient still complained of burning sensations in both lower extremities which, however, were stronger on the left than on the right side. The change of dressings disclosed a completely healed wound. The patient now sat up for the first time in a reclining chair, and she was also able to stand. Three days later (four and a half weeks after the operation) she requested to be discharged.

The results of the examination on the 21st of July, 1900, were as follows:

Sensibility.—The sense of pain was still somewhat reduced in the left lower extremity; while the point of the needle was correctly perceived, yet it was not as distinct as on the right side. The sense of touch was everywhere normal in the left lower extremity as well as in the zone of the right limb, fully described above. Back: the sensation of cold and warm was normal on the right lower extremity, while on the left cold was perceived as cold and warm, also as cold.

Motility.—Active movements of the right ankle-joint were strong and could be executed within normal limits. The patient was further able, while in the dorsal position, to flex the right thigh at the knee and hip to such a degree that the knee was almost at a right angle; she was also able to extend it actively from this position. When the knee was flexed at an angle of one hundred and fifty degrees and the thigh supported with the hand, the patient was able to fully extend the leg and to elevate it. Without support, however, the extended thigh could not be elevated at the hip-joint, nor could it be retained in that position when brought there by passive elevation. The functions of the muscles of the left lower extremity were normal. The muscles of both extremities were flaccid; this could be explained on the left by continued inactivity.

The active movements of the trunk did not suffer as a consequence of the removal of the arches of the 6th to the 9th vertebræ. The patient was able to sit up from a horizontal position without effort, and all movements of the trunk were performed well.

The functions of the bladder and rectum were normal.

Attempts at walking exhausted the patient considerably. When supported on both sides, she bent her trunk somewhat obliquely backward, elevated one lower extremity to soon place it down with the point of the foot first. The functions of the lower extremities were somewhat weaker on the right than on the left side.

Reflexes.—Distinct ankle-clonus was present on the right side. The patellar reflex was not exaggerated on the right. On the other hand, it was somewhat weaker than on the left.

Subjective Manifestations.—The patient still complained of burning sensations in both lower extremities which, as she stated, were most marked from the knee downward, and greater on the left than on the right side. Her appetite and sleep were good.

Six weeks later the patient was able to walk well and unsupported when using *Volkmann's* walking-stool. She was even able to step over the threshold. When in the dorsal decubitus, she lifted both her extremities well and with force.

I examined the patient in Berlin on the 3d of February, 1901, and the following conditions were found: The motility and power, especially of the right lower extremity, had in the last few months improved to such an extent, that the patient was even able to ascend stairs when supporting herself on the banister. She was able to walk well without any support outside of *Volkmann's* stool. The power to walk did not improve any further. The woman believed that her weakness in the knee and hip joints, especially on the right side, were due to insufficient force, and that the pains in the left lower extremity rendered her walking difficult. The latter were of a burning character and were located on the left side in the left lower extremity, especially in the sole of the foot. In the right lower limb, on the other hand, the pains were only slight, tolerable and localized to the toes and the knee.

The functions of the rectum were normal, and flatus was not expelled involuntarily as before the operation. The patient was mainly constipated and frequently resorted to cathartics.

She could retain the urine normally and was not compelled to evacuate her bladder even during the night. The frequent desire to urinate with involuntary evacuation of the bladder (imperative incontinence) from which the patient had been suffering before the operation, had completely disappeared.

She believed herself much improved after the operation. The most annoying symptom was the pain in her left lower limb. When she attempted to rise from a lying position, she perceived pains in the lower part of the abdomen. The girdle sensation was still present, but weaker and not nearly as painful as before. Its course was the same as before the operation, viz.: along the crest of the ilium. The painful sensation of tension in the sacrum had completely disappeared.

The face was still somewhat pale, her state of nutrition good, and the general musculature flaccid. The linear scar, the result of the operation, was 17 cm. long, freely movable on the underlying structures and not sensitive to the touch. When she was requested to lean forward, the furrow along the vertebral column increased in length to about ¾ cm. and measured then 11.25 cm. The spinous process of the 5th dorsal vertebra was the uppermost boundary of the cleft. In spite of the fact that the posterior wall of the vertebral canal was missing to so great an extent, not the slightest disturbances were complained of, and she kept her trunk erect, and the movements of the vertebral column were normal in every respect.

Tests of Mobility.—The coarse power of the right lower extremity was much less than that of the left. The patient was able when in the dorsal position to flex the right knee and to elevate the limb with difficulty. The power of flexion of the knee and extension of the foot, when resisted, were weaker than the movements of extension of the knee and flexion of the foot. Tests of muscular power showed it to be deficient. Active imitation with one limb of passive positions of the other were performed well, but they were executed better with the left than with the right extremity. The volume of the musculature was equal on both sides.

Tremors, fibrillary twitchings, and paralyses did not exist. The muscles and nerves of the lower extremities reacted to the faradic as well as to the galvanic current (CaCC > AnCC). On the right side somewhat stronger currents were required.

Sensory Tests (lower extremities and pelvis, hence below the tumor).—Contacts with the brush were everywhere perceived promptly; even those parts that were previously anæsthetic (situated above the crest of the ilium), now perceived the finest contacts with the brush. The patient said that the contacts were perceived in the left lower extremity "less distinctly" and that they "hurt" (hyperæsthesia). Pricks with the needle were everywhere perceived well, and the same subjective sensations were elicited as with the tests of contact. Contacts with the pin-point and the pin-head were not always correctly perceived, especially on the left side.

The temperature sense was normal on the right side, but on the entire left lower extremity contacts with heat were described as "warm," while the application of cold was described as "still warmer." On the left side the difference in the temperature sense from the hip upward was correct.

The woman complained of spontaneous neuralgic pains, especially on the left side in the region of the nervus cruralis and the nervus cutan. femor. lateralis. A decided sensitiveness to pressure along the large nerve trunks of the lower extremities did not exist.

Of the reflexes, that of pricking the sole of the foot, was distinct on both sides, and that of tickling the sole of the foot could not be elicited. On the left side the patellar reflex was as strong as on the right. This was also true with reference to the Achilles tendon reflex. Ankle-clonus, on the other hand, was not present.

During these observations the complaints of the patient were very variable, yet she was rarely entirely free from pain and she made constant use of *Volkmann's* stool. The greater the pains, the more difficult was her walk. Disturbances of the bladder and rectum could at no time be demonstrated. Under nervous agitation her pains became severer and her walk aggravated. These manifestations improved under treatment, so that the patient was discharged five weeks later.

On the 28th of December, 1909, the patient, who was at that time seventy-five years of age, was examined at her home by my chief physician *Dr. Emil Heymann.* She complained of pain in the lower extremities which, however, were not very severe, but interfered, nevertheless, with her complete well-being. She was unable to give a better description of the character of these pains. They would mainly occur during the day, and her sleep at night was undisturbed. Without *Volkmann's* walking-stool the old woman could not walk—she never attempted it after the operation. Her daughter volunteered the statement that in the last six months further progress in the improvement of her walk was noticeable. She walked through her residence, which consisted of four rooms, innumerable times during the day. Objectively the active movements in the various joints were entirely free, but they were somewhat weaker in the right lower extremity than in the left. The patient could not bring her right foot into a position of complete dorsal flexion. Sensory disturbances could not be demonstrated on the left nor on the right lower extremity. An aggravation in the general condition of the patient did not take place, despite her old age. Mood, general condition, appetite and sleep were excellent.

Résumé of the Diagnosis

The beginning of the disease with sensory symptoms of irritation, the gradually progressing sensory as well as motor disturbances to *Brown-Séquard's* unilateral lesion, the greater participation of the musculature than of the sensibility, all of these pointed to a slow but progressively developing space-restricting condition within the vertebral canal that compressed the spinal cord on the right side. The fact that there were in this case a number of deviations from the typical picture of a unilateral lesion such as is seen to result from a division of a half side of the spinal cord (for instance, the absence of hyperæsthesia on the paralyzed side, the absence of a reduction of the sense of touch on the opposite side and finally the incomplete paralysis of individual muscles), strengthened the probability of our assumption. It is natural to conceive that a gradually increasing intravertebral pressure would not put exactly a half cross-section of the cord out of function. For not all sensory nerve fibres cross each other immediately after they enter the spinal cord, with the exception of those of the sense of pain and temperature, while those of the sense of touch (contact) run at least in part uncrossed. The crossed fibres run upward in the antero-lateral column. The form of anæsthesia of the left lower extremity observed in our case conforms with this view. The nerve fibres of the muscular sense run as do the motor fibres in the cord uncrossed. This explains why the muscular sense in our patient was reduced on the paralyzed side.

With these facts in mind the natural diagnosis presenting itself was, of course, that of a slowly developing intradural neoplasm. Since the osseous vertebral column was perfectly normal despite the duration of the disease (a great many years), an affection of the column was entirely out of the question, and this could also be answered in the negative with reference to a tumor developing between the dura mater and the bodies of the vertebræ. If the latter structures become involved, manifestations of compression of the roots may, of course, be the only symptoms for a long time. In the further course of the disease, however, when the bones become affected, certain symptoms referable to an affection of the vertebral column become manifest, which in our patient was not the case at any time. Close scrutiny of the facts before us made a diagnosis of tumor in the interior of the dura, i.e., posterior and lateral (toward the right side)—a situation where intradural neoplasmata develop by preference—fairly justifiable. Furthermore, experience teaches that the picture of unilateral lesion of the cord is principally produced by neoplasmata of the spinal membranes. The slow growth of the tumor pointed to a relative benignancy.

After arriving at this conclusion the question of the level of the tumor (segment diagnosis) engaged our attention. The following facts pointed to its position: **The Presence of the patellar reflex** proved that the reflex arc in the 2d to the 4th lumbar segments was retained. The neoplasm could therefore not extend deeper, below the first lumbar segment. The exaggeration of the tendon reflexes of the right led to the same result. The reflex blocking influences descending from above had evidently been injured, the tumor had therefore interrupted the conduction above the 2d lumbar segment. This condition of the tendon reflexes was the only guide to point out to us the lower limit of the neoplasm and furthermore to ascertain the spinal segment below which the action of compression could possibly not have extended. All other symptoms which we shall discuss directly gave us clues to ascertain the upper limit of the tumor, because the manifestations produced by the neoplasm itself can only extend upward to a point corresponding to the morbid influences on the spinal cord and nerve-roots.

Of symptoms of the motor sphere there existed a total paralysis in the upper part of the right lower extremity. Even the ileo-psoas, which is innervated by nerves from as high as the 12th dorsal segment, was paralyzed. As stated before, the individual muscles are innervated from three segments of the cord. Since in the case under discussion there was a complete paralysis of the ileo-psoas muscle (I need only point out here the most centralward situated muscle) at least the 11th dorsal segment had undoubtedly been subjected to compression and the upper limit of the neoplasm corresponded to this situation.

The examination of **sensibility** offered the following points that helped us to arrive at a segmental diagnosis. With reference to symptoms of irritation at the upper limit, there existed a decided painful girdle sensation which, beginning at the sacrum, extended along the upper border of the pelvis to the front. This region receives its nerve supply from the 11th and 12th dorsal segments. The patient also complained of pains in the right hip. These pointed to an irritation of the 12th dorsal and the 1st lumbar segment. It should be recalled here that every root is intimately connected with the neighboring two roots (adjacent roots), and an irritation of one of the adjacent roots (lower root) for instance does not only affect the principal root but involves sympathetically the root above it. In such instances the symptoms of irritation will necessarily appear about two root regions higher than the position of the etiologic factor. From all experiences, however, this appears to occur only in instances where the patient complains of very extensive pains.

Clinical observation, at any rate, teaches that the girdle sensation is localized to about the upper limit of the neoplasm of the cord. Since in our case the girdle sensation involved the 11th dorsal segment, the upper limit of the tumor was, therefore, diagnosed to correspond to that region.

Of greater importance than the manifestations of irritation in segment diagnosis, are the **symptoms of interrupted conduction in the sensory tracts** which were also present in our case and which were mainly due to an injury of the spinal cord itself.

The sensation of pain was reduced in the left lower extremity in the front up to the external genitals (region innervated by the 1st lumbar segment), and behind to nearly the crest of the ilium (12th dorsal segment). There was also a disturbance in the temperature sense. The zone situated on the right side of the back between the sacrum and the greater trochanter about the breadth of a hand immediately above the crest of the ilium was for our observation of the utmost importance. In this region there existed **complete anaesthesia** to contacts with the brush, and distinct reduction of the sense of pain to pricks with the needle. These manifestations of disturbances of sensation clearly pointed that at least three neighboring root-regions were paralyzed, mainly the one corresponding to the anæsthetic zone innervated by the 12th dorsal segment and the regions situated immediately above and below, receiving their nerve supply from the 11th dorsal and 1st lumbar segment.

When we take into consideration the experimental and clinical experiences of *Sherrington* and *Bruns,* we must conclude that in order to ascertain the upper limit of the neoplasm, the anæsthetic zone found represented in our case the most important symptom. While the motor paralysis extended only to the 1st lumbar segment, the anæsthetic zone reached the 12th dorsal region. We were, therefore, obliged to assume that at least the 11th, and according to *Bruns* even the 10th dorsal segment were paralyzed, and we were consequently to look for the upper limit of the neoplasm in that region. We had finally to ascertain the arch of the vertebra or better, the palpable spinous process under which the tumor was situated. We have ascertained from the condition of the patellar reflexes that the lower limit of the action of the tumor on the spinal cord could not have reached lower than the 1st lumbar segment. Now then, according to *Reid,* this corresponded to the 9th and 10th spinous processes of the vertebral column, and according to *Gowers,* to the 11th, while *Henle* marks the place as being situated between the spinous processes of the 10th and 11th thoracic vertebræ.

We suspected the upper limit of the tumor to correspond to the 10th dorsal segment. According to *Reid,* this is situated opposite the 7th and 8th spinous processes, while the 9th dorsal segment, which we assumed in our case to be normal, corresponds with its middle portion to the level of the 6th spinous process. The 11th dorsal segment corresponds to the 8th; the 12th to the 8th and 9th spinous processes of the dorsal vertebral column. According to *Gowers,* however, the 10th dorsal segment corresponds to the upper border of the 9th spinous process and above it. According to *Henle* the 10th dorsal segment is opposite the spinous process of the 8th thoracic vertebra and below it, while the 11th is located between the spinous processes of the 8th and 9th thoracic vertebræ, and the 12th opposite the process of the 10th thoracic vertebra.

In view of all these facts, the tumor could not have extended lower than the 9th or 10th thoracic vertebra, and its upper limit was to be looked for at the spinous process of the 7th dorsal vertebra. The operation proved that the tumor, which was 17 mm. in length, corresponded with its middle portion to the level of the arch of the 7th thoracic vertebra; therefore, in the sense of *Henle*, to the 9th dorsal segment at its upper border, to the 10th according to *Reid*, and to the 8th according to *Gowers*.

Our case corresponded with the picture of *Brown-Séquard's* paralysis. The paralyses and anæsthesias have mainly disappeared after the removal of the tumor. The slight remnants of these manifestations may be explained by the fact that certain fibres, which according to the anamnesis have been subjected to pressure for at least three years, were destroyed. Finally the cure of the patient, who was seventy-five years of age, remained stationary for a period of ten years.

OBSERVATION XIII, 2[1]

Fibrosarcoma of the Spinal Membranes at the Level of the Second and Third Arches of the Cervical Vertebræ Extending Downward to the Fourth. Extirpation of the Tumor and Removal of the Second to the Fifth Arches of the Cervical Vertebræ. Cure.

The patient in this case was a medical student, who was twenty-three years of age at the time of the operation. He perceived the first pains on the right side of the neck in the fall of 1903. About a year later they became more intense and lasted for a longer period, and they also extended to the left half of the neck as well as into the right arm. At walking, riding and jarring, the pains of the neck were especially severe. From December, 1904, on, they interfered with the sleep of the patient so that, since the beginning of February, 1905, he was unable to sleep without injections of morphin. In the spring of 1905 he was confined to an extension apparatus for ten weeks. This improved the pains to such an extent that after the application of an isinglass bandage he was able to be out of bed for *five* or *six* hours daily. He went then to Salzuflen, a watering-place, where in August, 1905, his condition became so much worse that he had to remain in bed for a number of weeks. In the spring of 1906 his general condition was very much better, so that he was able to sojourn from his home (Barntrup) to Hannover. He walked about with a cervical and spinal supporter.

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[1] Observation XIII, 2 and 3 are published in detail: *H. Oppenheim* and *F. Krause*, Fortgesetzte Beiträge zur Neurochirurgie. "Münch. med. Wochenschr.," 1909, Nos. 20–22.

In the following summer semester the patient resumed his medical studies. He took care of himself, attended two lectures in the morning and took short walks in the afternoon. Even during the first part of the summer vacation he felt very good and was able to walk about for hours. At the end of October, 1906, however, the first manifestations of weakness of the right hand were noticed and it was said that in the beginning the deltoid remained free. A few months later the same manifestations were also observed in the left hand. In the beginning of the winter term he was still working in the department of anatomy. His condition, however, became aggravated so that about Christmas, 1906, the weakness in the right arm and in the right hand had considerably increased, and he was unable to hold a knife. The right lower extremity was also sympathetically affected, and walks tired him on account of the weakness in the limb. Rest in bed and *Glisson's* sling were ordered.

The nights were bad in spite of veronal. In February, 1907, a rapidly increasing weakness in the left arm was observed, so that the patient was hardly able to use it. From that time on, the entire right arm was completely useless. Twitchings of both arms and lower extremities gradually developed. From May, 1907, on, the patient could only walk when supported. The sensitiveness in the neck and in the arms had considerably increased. In the fall of 1907 there was a striking aggravation in the general condition and, when he attempted to stand or walk, his lower extremities trembled very much. The twitchings in the extremities became more frequent and of a severer grade as were also the pains in the neck. At the end of December, 1907, the

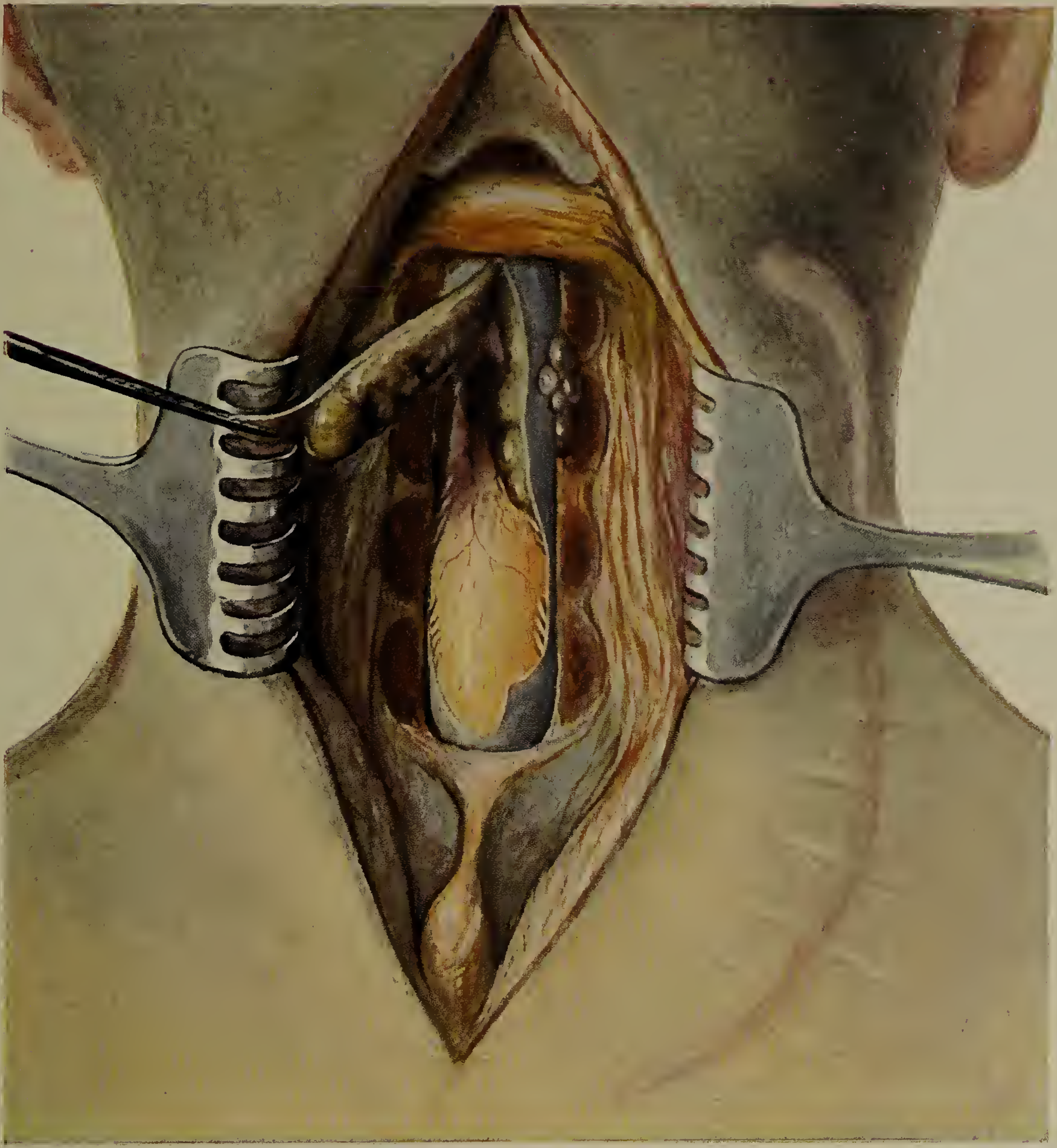

Fig. a.

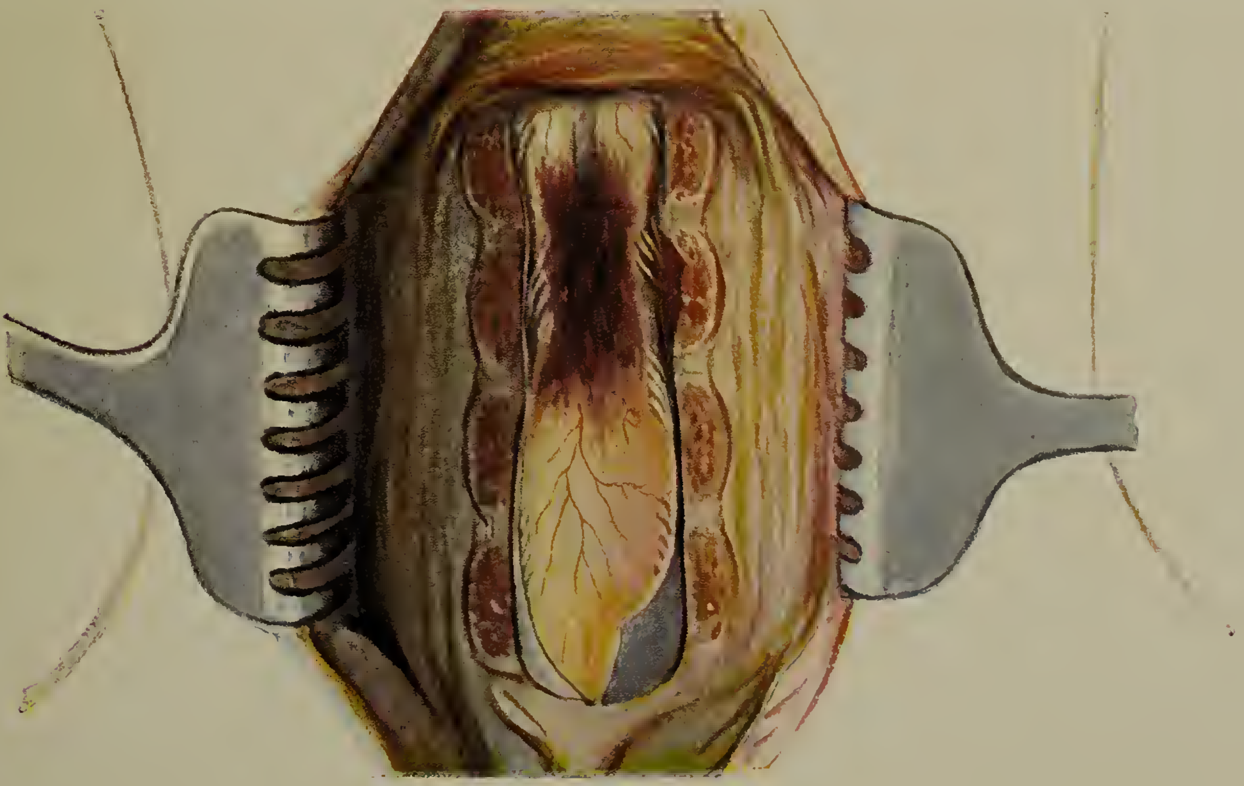

Fig. b.

Rebman Company, New-York.

patient, who at that time could only walk four or five steps when supported, was brought to a certain university clinic. There, two operations were performed, one on the 2d and the other on the 20th of February, 1908, and the arches of the 3d, 4th, and 5th cervical vertebræ partly removed, **the dura evidently not opened** and the **tumor consequently not found.** Since no improvement in the condition of the patient ensued, he was brought to the surgical division of the Augusta Hospital of Berlin on the 17th of May, 1908. Repeated examinations by *Professor Hermann Oppenheim* and ourselves revealed the following conditions:

The pulse was 115, regular and moderately tense. The patient complained of palpitation of the heart, of strong pains in the back of the neck and in the left region of the neck, and when he moved or was jarred he complained of paræsthesias in the arms, especially the left, and of a sense of paralysis in arms and extremities and difficult urination. During the examination he was found in a horizontal dorsal decubitus with an extremely rigid, perfectly straight, vertical attitude of the head. He was able to turn the head a little sideward, a little more to the right than to the left. When he turned it over these limits, pains were at once complained of. The arms were in a position of adduction. When the patient was lifted up in a sitting posture the head persisted in the same rigid, vertical position.

Tests of the cerebral nerves disclosed that there was, outside of a slight strabismus convergens in the motor regions of the trigeminus, a distinct deviation of the lower jaw to the right when the patient was opening his mouth. He was also able to elevate his shoulder somewhat better on the right than on the left side. The function of the cucullaris was otherwise normal.

A scar, the result of previous operations, extended from the right mastoid process to the shoulder-blade on the side of the neck in an arched manner (see Plate XLIX, Fig. a). To the left of the spinous process in the region of the 5th cervical vertebra there was a round elevated area of greater resistance. Pressure on this place was somewhat painful and the percussion sound somewhat shortened. The spinous processes of the upper cervical vertebræ, from the 4th down, were very deep and could not be palpated distinctly.

The region of the deltoids were very much flattened and their function entirely extinguished. The hands were in a position of extension; this was especially marked on the right. Its coarse power was weak to such a degree that it could not be measured with a dynamometer. The thumbs were adduced, the fingers of the right hand in a claw position, the angles of which were increased toward the 5th finger. The anomalous position was less marked in the left hand. Marked atrophy of the small muscles of the hand was found on both sides. The function of the interossei, lumbricales and the thenars appeared almost completely extinguished. The musculature of the extensor surface of the forearm was also wasted.

Extension of the right hand was executed with minimal power, but it was somewhat stronger than flexion. The extensor digitorum communis showed some strength. Flexion of the fingers with the exception of the thumb and index finger was fairly complete but it was accomplished with little power. A high degree of motor ataxia was observed in the right arm. The adduction of the arms was executed with almost normal power, inward rotation of the right arm was also powerful, while outward rotation was weak. The movement of inward rotation of the left arm was also retained, but outward rotation was entirely gone. Flexion and extension of the forearm were considerably diminished. The paresis and atrophy of the muscles of the left arm corresponded to those of the right, but to a much less degree. The cubital reflex was considerably exaggerated on both sides.

The abdominal reflex as well as the cremasteric reflexes were absent on both sides and the abdominal muscles performed their functions weakly. The function of the phrenic was normal.

A spastic condition existed in both lower extremities, especially the left. Patellar- and ankle-clonus, *Babinski, Oppenheim,* and *Bechterew-Mendel* signs were present on both sides. The paresis of both lower extremities was complete, considerable on the right with not much difference between the two sides, but somewhat weaker on the left. The patient was unable to stand or walk even when supported on both sides.

The result of the examination of sensation was as follows: On the trunk tactile anæsthesia extended upward over the mammillæ. Contacts with the brush were perceived correctly only to the lower border of the 2d rib, tolerably well to the intermammillary line, and after that not at all. The difference of contact between the brush and its metal handle could not be distinguished on the arms and below the 2d rib. In this locality the sense of pain was also diminished. In the front of the body, from the intermammillary line to the hip, the difference between cold and warm could not be distinguished.

The disturbances of the tactile sense on the right upper extremity were considerable, especially in the forearm and hand; its definite localization was difficult to accomplish. The analgesia extended almost all over the entire right arm to the axillary region. On the left side the tactile anæsthesia affected more the ulnar regions; the analgesia was here less extensive and not as marked. The disturbances of the sense of temperature on the left arm were slight while on the right forearm, extending over the elbow, the difference between warm and cold could not be distinguished by the patient. The stereognostic sense was completely extinguished.

The faradic test showed severe quantitative disturbances on the right arm, total abolition in the median region, especially in the flexors of the fingers, the thumb, the median lumbricales and the opponens pollicis. The disturbances in the ulnaris region were less marked and also in *Erb's* muscles, of which again the deltoid was mostly affected. The left arm presented approximately the same picture, but, on the whole, it was less intense, and the musculature of the median region was not entirely irresponsive to the current. Contacts with the brush were perceived at both lower extremities. The sense of pain was almost everywhere gone and the temperature sense of both legs was much reduced but not completely abolished. The sense of position of the big toe was disturbed on both sides.

Hyperidrosis was found in both hands, especially in the right.

A hyperæsthetic zone was found on the right side of the neck extending from the region of the clavicle to the ear, and ceased exactly in the median line. Occasionally pricks with the needle were perceived in the fossa supraclavicularis with more pain than in other portions of the skin. The patient was here so sensitive that he could not bear to come in contact with anything.

He stated that marked hyperæsthesia existed in the right arm before he came under our observation.

As a result of the findings of the examination here detailed, the diagnosis of *H. Oppenheim* was as follows: "Neoplasm in the region of the middle and lower cervical cord, the upper limit of which corresponds to about the 5th cervical nerves. While a decision whether the tumor springs from the cord itself or from the meninges in its vicinity cannot be given with certainty, the latter assumption appears the more probable. In either case an operation is indicated. Even if the tumor be intramedullary, the operation will bring benefit by decompression." At a subsequent examination *Oppenheim* was more certain of the extramedullary seat of the neoplasm.

I performed the operation on the 30th of May, 1908, with the patient anæsthetized with chloroform. The position of the patient was half abdominal on the right side, in which position he was held throughout the operation, but to avoid interference with the respirations he had to be turned on the back now and then. The incision was made in the median line and extended from the protuberantia occipitalis externa to the vertebra prominens, and it was about 18 cm. long. I guided the knife with extreme care through the cicatrized muscular layers on account of the previous operations and finally exposed the uninjured lower spinous process and arch of the vertebra, which proved later on to be the 6th cervical vertebra. After the posterior surface of the 6th arch was exposed, a normal looking strip of dura mater about 2 mm. wide was exposed at its upper border. The indurated scar was now caught with a pair of hooks, made tense by pulling upon it, and with careful strokes of the knife directed from the left to right, cautiously dissected away from the dura underneath it. I continued this dissection from below upward and was successful in exposing the entire region of the previous two operations (2d and 20th of February, 1908). After this the dissected scar was transversely cut away from the split spinous process of the epistropheus.

Despite all care, however, the external surface of the very tense dura, showing no sign of pulsation, was casually scratched at the level of about the 4th arch on the left side to an extent of about ½ cm., but it was not opened completely. At this point it appeared as a bag under marked tension filled with a liquid; the former was evidently composed of the inner layer of the dura and the adjacent arachnoid parietalis.

The findings of the previous operations were finally as follows: The arches of the 4th and 5th cervical vertebræ were found removed but laterally not as far as their junction with the bodies; of the 3d arch a median portion, measuring about 1 cm. in width, was absent together with the spinous process. The rest of these three arches were finally bitten off in typical manner laterally with various rongeur forceps, so that the tense dura, measuring 7 cm. in length and 42 mm. in width (measured over the convex prominence), lay freely exposed. It showed no trace of pulsation. Below, its appearance was normal, above and especially to the right, indurated. Palpation showed, especially in the right upper region about the level of the 4th arch, a distinct resistance which imparted the impression of an induration of medium hardness. Entirely to the right at the lower border of the 3d arch a spherical neoplasm of violet-gray color, resembling a sarcoma projected over the external surface of the dura for a distance of 3 mm. The dura was now split in the median line below and in its lower section a stream of liquor cerebro-spinalis projected, and a great quantity of that fluid was evacuated —hence, **accumulation of liquor below the neoplasm.** (Plate XLIX, Fig. a.)

The tumor began at the level of the 4th arch. It extended to the right to the borders of the cut surfaces of the bone and on the left side close to these, and had therefore occupied the entire width of the dura. An extirpation *in toto* would in this particular (cervical) region have been very dangerous on account of the posterior nerve roots. I therefore preferred to split the dura from below upward in the median line and in this manner to divide the tumor into two halves which were, proceeding from the median line outward, bluntly dissected away without much difficulty from the posterior surface of the spinal cord with closed scissors. At this stage of the operation I had not as yet reached the upper limit of the tumor. The arch of the epistropheus had therefore to be removed. For that purpose I made an incision into the bone right and left from the lower border upward with my cutting forceps (see Fig. 158, p. 962);

the rest of the arch was now divided with the large cutting forceps of Horsley (see Fig. 161, p. 964). Both of these instruments worked excellently in this dangerous region and with care. After splitting the dura together with the tumor in the median line as high as the lower border of the atlas, the upper border of the neoplasm lay exposed. We were, therefore, not obliged to remove any portion from the lower border of the posterior arch of the atlas. The tumor together with the dura to which it was attached at the inner surface were cut away. The 4th posterior root on the right side traversed the tumor and was, therefore, resected. Only a slight quantity of liquor drained away from above the neoplasm and the sac of dura in that situation was pulsating, therefore—**no accumulation of liquor above the neoplasm.**

The tumor was grayish-red in color, semisolid, and a number of bloody suggulations were found on its anterior surface. It had created a wide and deep cavity in the spinal cord immediately above the visible cervical enlargement. This cavity was brownish-red in color and showed also hemorrhagic suggulations (see Plate XLIX, Fig. b). After the extirpation and much shrinkage the length of the tumor was 42 mm. and its breadth and thickness, which increased after its removal, were 30 and 10 mm. respectively.

Since the dura mater had to be cut away to a great extent, the exposed cervical cord could only be covered with musculature. Four interrupted sutures of silk were now introduced at the beginning near the border of the incision and penetrating the entire thickness of the muscles down to the remnants of the arches. A number of other sutures were introduced between the former which did not extend so deeply. At the lower angle of the wound I introduced a short drain which was removed four days later. After the operation the patient was much collapsed and his pulse was 160. On the following day he improved remarkably so that subjectively he felt quite well, but his pulse was still small and about 120 beats per minute. His temperature was normal. He did not vomit and he evacuated his bladder spontaneously. Diaphramatic breathing was complete and extensive, and there was no dyspnœa. This favorable improvement continued until the 6th of June and the pulse-rate gradually dropped. On that day the first change of dressings was made (about one week after the operation), and the wound was found completely united, with the exception that underneath the musculature a fluctuating accumulation of liquor cerebro-spinalis was present. Two days later I opened a suture tract about the middle of the wound and from this opening cerebro-spinal fluid was draining in variable quantities for a period of about three weeks. This brought the patient in great danger. After that the small fistula healed spontaneously.

I am giving here the following condensed abstract of the minute and extensive examinations, for which we are largely indebted to *Professor H. Oppenheim:*

With reference to *motility,* there was found on the day after the operation (May 31st) an absence of extension of the forearm of the right upper extremity while extension in the wrist-joint could still be executed but with very slight power. The motility of the lower extremity was certainly not worse than before the operation. On the 3d of June the patient was able to reach with his hands (especially the left) the point of his nose; this, of course, under trembling and considerable ataxia. He was also able to move the thumb of his left hand with greater force. On the 9th of June he could abduce his left arm at the shoulder-joint and bring it to the horizontal position, and he was also able to reach his forehead with the hand. Motor ataxia was distinct in both hands but it was less than before.

Generally speaking, all active movements, especially that of the left upper extremity, had somewhat improved in power and mobility. The motility of the lower extremities was so far improved that the patient was able to extensively move his feet and toes. On the 27th of June the patient was also able to abduce the right arm to almost a horizontal position. Flexion and extension of the right forearm were fairly extensive and powerful; this was also the case in the right wrist-joint. The function of the extensor digitorum communis was good. However, there still existed a claw position of the fingers. The patient was, nevertheless, able to almost completely extend his four fingers, but flexion to a point of closure of the fist could not be accomplished. The movements of the right hand were accompanied by a fine tremor. He was able to abduce his left arm to a horizontal position. All other movements of the left upper extremity as well as that of the right were performed, but much more extensively and with greater power in the former. At that time the patient was able to hold objects with his left hand so strongly that it was difficult to pull them away from him. At the examination with the patient in bed active movements of the right lower extremity were still deficient, but with the exception of limited movements of the hip they were performed to full extent with considerably reduced power, of course.

On the 4th of July the mobility of his arms, especially of the left, had still more improved. The patient was able to bring his left hand to the back of his head and with his right he could touch the forehead. The mobility of the right thumb was also more extensive. The claw position of the left hand had entirely straightened out and the patient was able to spread and adduce the fingers of the left hand. On the right side he could do this less completely and with effort. The claw position was here still persisting to a slight degree. All movements of the right upper extremity were accompanied by strong, fine tremor.

The coarse power of the lower extremities was about normal, especially when the general weakness and the malnutrition of the patient were taken into consideration.

The coordination in the left lower extremity was normal and in the right still uncertain. The ataxia was quite distinct in both hands but by no means as strong as before; however, at the finger-touch-nose-test he invariably brought his index finger to the eye.

On the 8th of July the ataxia in the right hand was less and the left hand showed much improvement. With the latter he was able to grasp the examining fingers. He accomplished this less completely and with slighter power on the right side. The tremors on both sides were also less. The range of mobility on the left side had improved. On the 29th of July the movements of the head to left and right were fairly extensive to about an angle of thirty degrees and while executing them, the patient complained of no pain. Forward and backward bending of the head was accomplished slowly, but to quite an extent. The other movements of the face and head were unrestricted and the movements of arm and hand were free in all joints. Flexion of the right hand and of the right fingers was still restricted but the claw position had fairly disappeared. The patient was able to reach the parietal region with his right hand and the right ear with his left. The coarse power had considerably increased. The movements of the trunk were free on all sides and those of the extremities were performed in all joints. The power in the right hip was less than that of the left, but generally speaking the coarse power of both extremities was good. The finger-touch-nose-test was still unsuccessful and the ataxia was only marked in the right hand.

About the time of his discharge from the hospital the patient could walk from his room to the garden with slight support. The position of his lower extremities was slightly flexed but normal. Active movements of the right lower extremity were performed to the full extent with almost normal power. A paresis did no longer exist or was, at any rate, extremely slight. The general weakness of the patient, on the other hand, and his exhaustion were apparent. The movements of the head were considerably restricted on account of the mechanical interference as a result of cicatrization. Slight tremors in the hands still persisted. The muscular atrophy, especially the small muscles of the hands, was distinct and the position of the fingers was not as yet normal; the right hand still showed a slight tendency to claw position. However, the patient was able to voluntarily straighten out these anomalies of position. He was able to elevate his right arm to over the horizontal position, but as yet with reduced power. Adduction as well as flexion of the forearm were performed with full strength. Extension of the forearm showed the power reduced. The active mobility of the hand and fingers had markedly increased and was very near normal, and the patient was now able to clench his fist. Almost all movements were performed to a satisfactory degree with the exception that now and then a slight weakness of the terminal phalanx of the thumb was observed at extension and flexion. Elevation of the shoulder-joint on the left side was better than that of the right. There still existed a slight motor ataxia of both hands. On the 14th of September the patient was able to write me a long letter with his right hand.

Sensibility.—On the day after the operation the hyperæsthesia in the region of the supraclavicular fossa was much weaker. It persisted to a slight degree on the 3d of June, and on the 4th of July it had completely disappeared. On the latter day the pains in the lower extremities and in the abdomen had also ceased. Two days after the operation (1st of June) contacts with the brush were perceived everywhere on the right arm with the exception of the radial half of the volar surface of the hand and forearm. The patient perceived pricks with the needle on the hand and fingers distinctly and in the median region not as painful as in the ulnar region. Heat and cold were perceived correctly near the axilla only. On the left arm pricks with the needle and contacts were perceived correctly. On the 9th of June the patient was able to distinguish all over the upper right extremity between contacts and pricks, but there still existed a decided bathyanæsthesia in both upper extremities. Disturbances in the sense of position in the right hand and in the left lower extremity could be demonstrated on the 4th of July, while in the right hand normal conditions were observed. On the same day the difference between hot and cold was distinctly perceived by the patient in both hands and in the lower extremities. The difference between thermic qualities was correctly recognized on the trunk.

On the 29th of July contacts with the brush as well as point and blunt were differentiated everywhere correctly. Heat and cold were also recognized in all parts precisely, with the following exception: On the right in the region of the nervus cutaneus antibrachii lateralis over the radius down to the hand the patient always perceived cold for warm and occasionally the reverse. The stereognostic sense had not as yet returned in the right hand, but the sense of position and the muscular sense were intact. In the beginning of August he was entirely free from pain and perceived paræsthesias nowhere. The hyperæsthesia of the neck had completely disappeared. While the sensibility for contacts and pricks with the needle was, together with the sense of location, normal in both hands, a slight degree of disturbance of the sense of position could still be demonstrated in the fingers. The only abnormality demonstrable in the lower extremities especially in the right was a distinct reduction in the sense of position.

Hyperidrosis persisted in both hands.

The condition of the reflexes was as follows: On the 31st of May the knee phenomenon was still lively on both sides, the *Babinski* and *Oppenheim* reflexes could no longer be elicited, while *Bechterew-Mendel* sign could still be distinctly demonstrated. On the 27th of June no rigidity could be demonstrated in both lower extremities; on the contrary, it was more a condition of hypotonia. The tendon phenomena were moderately exaggerated and a trace of ankle-clonus was still present. On the 29th of July the tendon-periosteal reflexes of the upper as well as of the lower extremities were highly exaggerated and the *Bechterew-Mendel* sign persisted. The cremasteric and abdominal wall reflexes could not be elicited. On the 11th of August the tendon phenomena of the right arm were weak, but on the left they were exaggerated. With the patient in the dorsal position no hypertonia of the lower extremities was shown. The muscle tonus was reduced. The knee phenomenon was still somewhat exaggerated. There was tremor in the right foot, not in the left. *Babinski* and *Oppenheim* were negative while *Bechterew-Mendel* sign was present on both sides.

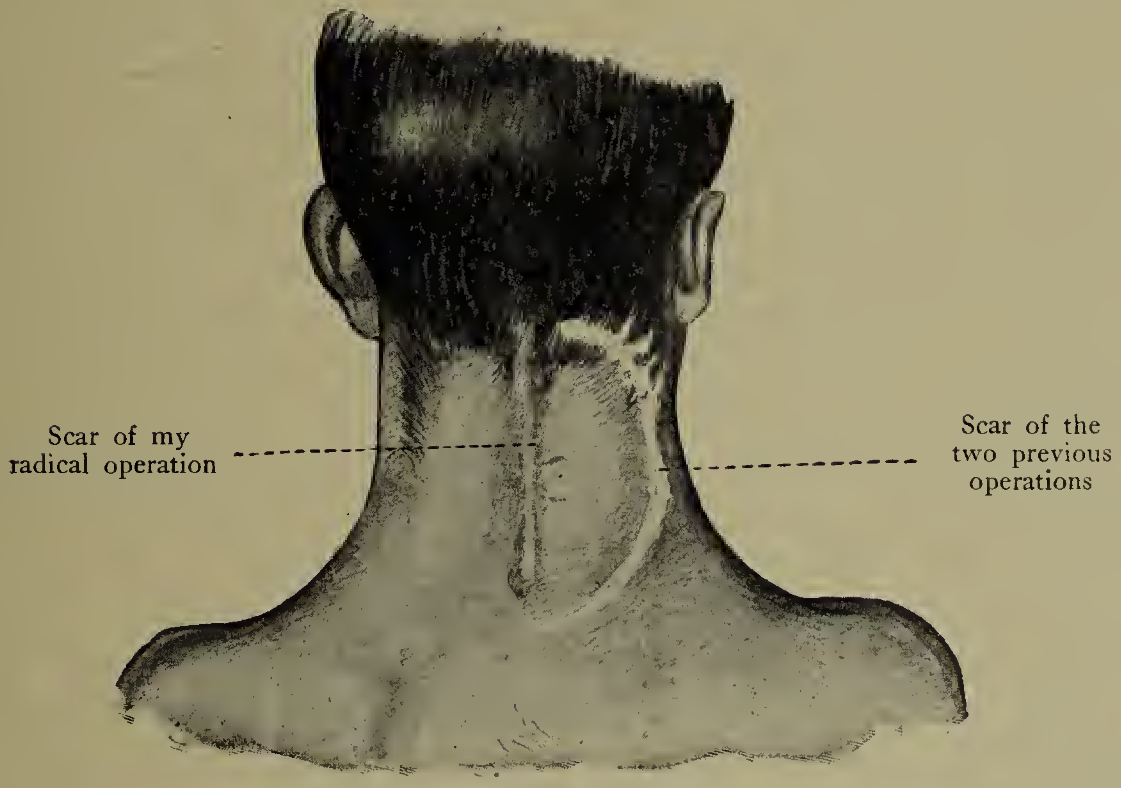

Fig. 169

About the middle of August, 1908, the patient was sent home, and on the 10th of December he presented himself and the following conditions were found: The position of the head was somewhat rigid; the movements of the head to the front and back as well as motions of rotation were restricted but could be performed without interference. It should be kept in mind, however, that the first surgeon had divided the muscles in the back of the neck on the right side transversely (see Fig. 169).

The hyperæsthesia in the region of the neck on the right side had disappeared. The musculature of the arms was somewhat deficient, but there was no localized muscular atrophy. The claw position of the fingers had completely disappeared on the left side, and on the right a trace of it was present. The active mobility in all muscular groups of the upper extremities was retained, only the right hand remained somewhat behind with reference to energy of movement and force. There was no ataxia in the arms, but a fine tremor in the hands. The sensibility of both hands, especially the sense of position, was normal on both sides.

In the lower extremities there was no rigidity, ataxia, clonus, *Babinski* nor *Oppenheim*. Only on the right side *Bechterew-Mendel* was present. The knee phenomena were normal. The active mobility of the lower extremities corresponded to the normal. The sensibility also showed no deviations from the normal.

The patient was able to walk for a number of hours and his gait, outside of the rigid position of the head, was perfect in every way. On the 16th of August, 1909, at the 1900 annual celebration of the War in the Forest of Teutoburg, the patient ascended the Hermann monument without the slightest difficulty. In November, 1900, he resumed his studies of medicine. Taking everything into consideration, we are justified in speaking of this case as a complete cure.

The development of the disease in this instance proceeded extremely slowly. In the beginning the pains were in the region of the back of the neck, thence they gradually spread to the right and then to the left arm, and for a period of three years they were the only clinical manifestations of the disease. In the further course of the trouble paralytic manifestations as a result of compression of the cervical cord set in. The fact that the recuperation was so rapid and that within a few months the patient was almost completely restored to health despite the fact that the cervical cord had been subjected to so severe a pressure for a number of years, deserves special mention. It is also a remarkable fact that the phrenic nerve, the roots of which spring from the region of the cervical cord, and which in the present case was subjected to the greatest pressure, did not suffer in the least. Even the manipulations of the cord during the operation, which, to be sure, were carried on with the greatest care, did not affect the fibres of the phrenicus in the least.

It is of special importance to the surgeon to note that the use of an extension apparatus had considerably improved the pains in the beginning of the trouble. *Oppenheim*[1] has, in one of his previous works, shown that in the later stages of extramedullary neoplasmata, when paralytic manifestations had already set in, such measures may prove harmful.

Manifestations of motor ataxia were noted during the period of healing. For these consult also the conclusion of Observation XIII, 3.

OBSERVATION XIII, 3

Fibroma of the Arachnoid, Rich in Cellular Elements at the Level of the Arches of the Sixth and Seventh Cervical Vertebræ. Operation on the 17th of June, 1907. Removal of Both Arches. Cure.

A man, twenty-nine years of age, was referred to me for operation in June, 1907, by *H. Oppenheim.* The first manifestations of the disease were noted in July, 1905. At that time the patient complained of pains in the region of the right elbow-joint, which occurred in the early hours of the morning and were of variable intensity, and in April, 1906, they were most severe and extended to the right shoulder. In the summer of the same year a weakness of the right arm was added and the pains spread, accompanied by weakness, unto the left arm. On account of the appearance of rigidity of the back of the neck, a diagnosis of rheumatism of the intervertebral ligaments of the cervical portion of the spinal column was made at that time. Accordingly a whole series of scars and pigmentations were found along the back of the patient from *points de feu.* In January, 1907, a certain rigidity and weakness were found in the lower extremities, especially in the right, so that in April of the same year the patient was unable to walk. Gradually difficulty in urination developed. The pains in the right arm, on the other hand, disappeared and recurred occasionally in the right shoulder. A gradually increasing weakness of the entire right upper extremity set in. Besides that, since May, 1907, the patient could not have a bowel action without resorting to cathartics. In studying the etiology of this case neither syphilis, alcoholic excesses, nor injuries could be found.

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[1] "Berlin. Klin. Wochenschr.," 1902.

On the 13th of June, 1907, *H. Oppenheim* found the following conditions: Both arms were weak and the lower extremities were paralyzed. When the latter were moved passively, twitchings were observed. When the patient was sneezing, the pains in the right shoulder became more intense. The existing urinary disturbances consisted of dysuria and more rarely of incontinence. The patient did not complain of greater paræsthesias. An absence of tactile sense in certain regions he had observed himself. For about two years past he kept his head rotated somewhat to the left side. The passive movements of the head were free, with the exception of flexion of the head to the front, which was restricted. Pressure upon the transverse processes of the cervical vertebræ above the clavicle was found painful.

The muscle tonus of the right arm was reduced, and in the left it was normal. On the right side the supinator and triceps phenomena were totally absent, on the left only the latter. The musculi interossei of both hands were atrophic, especially of the right, in which the flexors of the ulnar side of the forearm were also affected. With reference to active mobility, *Erb's* muscles were normal on the right arm, and the triceps extremely weak. Pronation and supination of the same hand were good and flexion in the wrist-joint was executed weakly. The extensor digitorum communis was paretic. The greatest paralysis was found in the interossei and lumbricales. Hyperextension and abduction

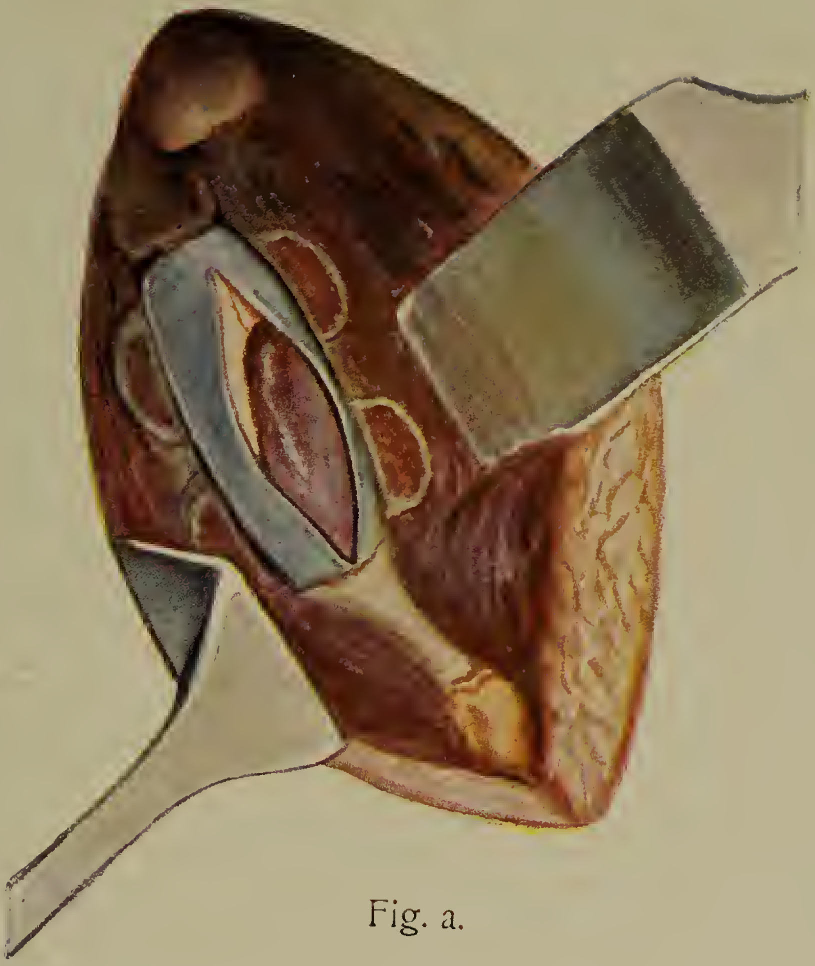

Fig. a.

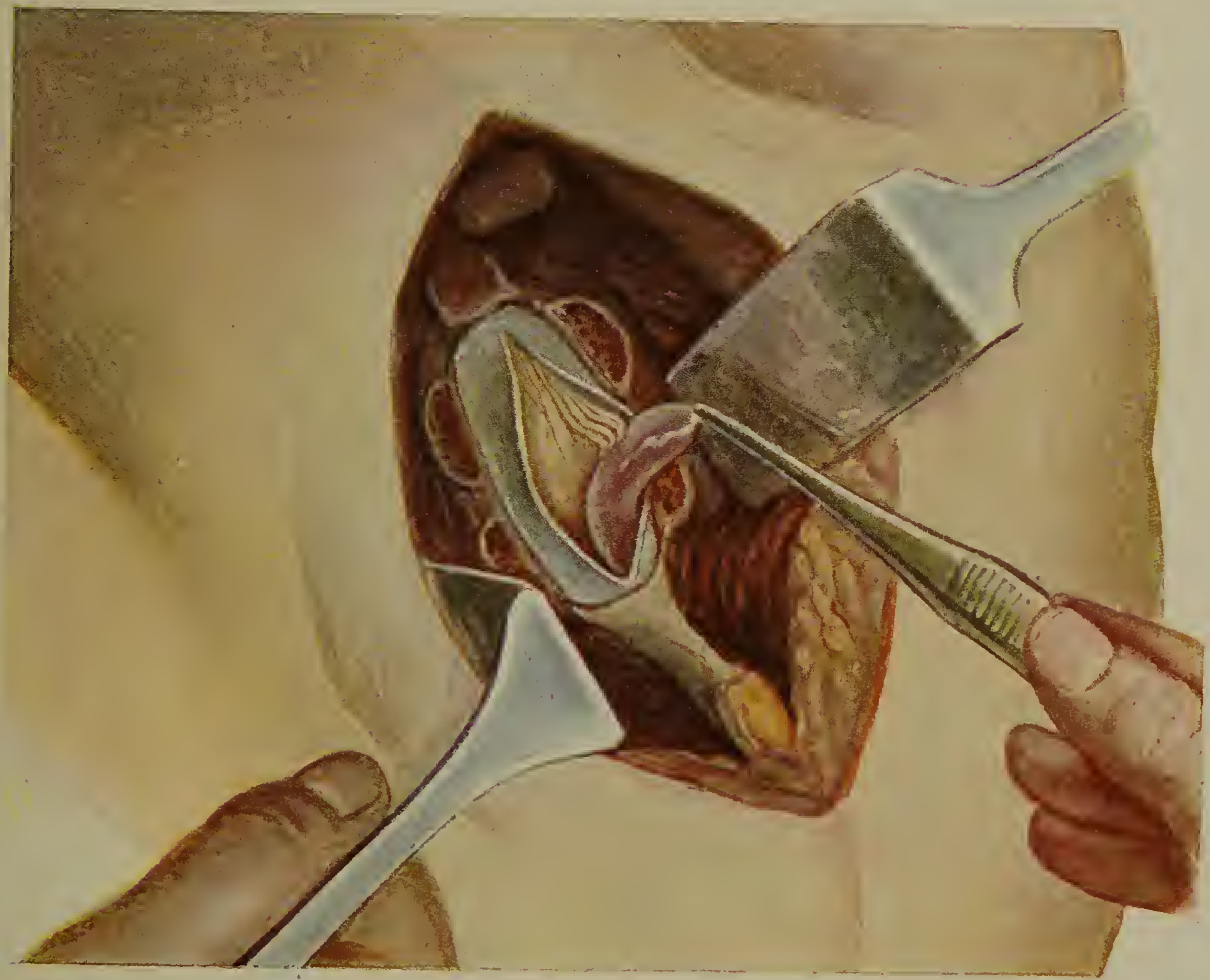

Fig. b.

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of the thumb were considerably damaged, also its long flexor, but to a less degree. Flexion of the 2d and 3d fingers was almost impossible. There was claw position of the hand. Similar paralytic manifestations existed in the left arm but, on the whole, they were less marked. The function of the triceps was very deficient; supination and pronation as well as extension of the hand were good; the flexion of the hand was moderate and that of the fingers affected. The abduction of the thumb was almost completely extinguished, the extension of the thumb and the other fingers gone, and the flexion of the 2d and 3d phalanges deficient. The claw position of the fingers was only slightly developed.

The disturbances of the faradic irritability were not very marked. The greatest reduction was in the triceps. The galvanic test resulted in the right triceps in a marked lightning-like ACC, in the flexor sublimis digitorum in a sluggish ACC = KCC, and in the 3d and 4th interossei in a sluggish ACC.

On the right, contacts with the brush were not perceived almost to the middle of the flexor and extensor surfaces of the entire ulnar region of the arm, forearm and hand. In this region a hypalgesia was present and on the little finger an analgesia which extended to the adjacent two fingers. The back of the hand up to the 3d metacarpus was also hypæsthetic. In the left hand the hypæsthesia was confined to a smaller area, i.e., it comprised the region of the 4th and 5th metacarpus and the 4th and 5th fingers; it extended volarward to the middle of the hand and the 3d to 5th fingers. The sense of pain and temperature were disturbed in these regions on the right as well as on the left arm, and the sense of position of the 4th and 5th fingers on both sides was entirely gone.

Both lower extremities were in rigid extension contracture, and the feet in "point foot" position. There was an œdema of the feet and legs—on the right more than on the left. Marked tremors of both feet. *Babinski* and *Oppenheim* positive on both sides. Within the last week the paraplegia of the lower extremities became total. With the exception of a few regions there was complete anæsthesia of the right thigh, which, extending upward to the trunk, terminated at the upper border of the third rib. Pricks with a needle were not perceived as pain in the sole of the right foot but as a cold sensation. Analgesia was otherwise within the same limits as the anæsthesia. The sense of position in both feet and toes was much disturbed—on the right more than on the left side, and a few days later it was entirely extinguished. For the sense of temperature, pain and contact, the upper limit was identical; on the back this could be well represented by the spine of the scapula. The abdominal wall and cremasteric reflexes were also absent.

The musculature of the back of the neck was everywhere flattened, especially on the right side. The spinous processes were not painful on pressure, yet pressure over the transverse processes of the cervical vertebræ at the level of the 6th and 7th were painful on both sides. The patient also complained of pain at the right superior internal angle of the scapula.

The ophthalmoscopic findings showed no deviations from the normal, and the X-ray examination was also negative. Both palpebral fissures were somewhat narrow and could not be sufficiently widened. There were no differences in the pupils and their reaction to light was normal. In the earlier stages of the disease the attending physician observed the right pupil somewhat wider than the left.

The diagnosis of *H. Oppenheim* was as follows: "We are dealing with a neoplasm or a similar process which is located in the lower cervical cord and which originated from the right side. While it is impossible to ascertain whether the tumor is extra- or intra-medullary in nature, the former assumption is by far the more justifiable. The region involved is that of the 8th cervical segment, yet the 7th is also affected to a limited extent. Laminectomy must, therefore, be performed on the 7th cervical vertebra and possibly also on the 6th. The differential diagnosis rests between neoplasm, pachymeningitis cervicalis hypertrophica and local meningitis serosa. The first is by far the most probable."

The operation was performed on the 17th of June, 1907, with the patient in chloroform narcosis. The skin and subcutaneous fat were divided in the median line over the spinous processes to a length of 14 cm. in such a manner that the middle of the incision corresponded to the spinous process of the 7th cervical vertebra. This was followed by the exposure of the arches of the 6th and 7th cervical and the 1st thoracic vertebra. This was difficult to accomplish because the cervical portion of the vertebral column was convexly curved to the left; the spinous process was very wide and split, and the depth of the wound was necessarily very deep on account of the heavy and uncommonly developed musculature.

For better guidance, a portion of the spinous process of the 7th cervical vertebra was removed with the rongeur forceps. The arch of the 7th cervical was now perforated to the right and left side of the spinous process, the rest of the arch divided with *Horsley's* forceps, and its removal completed with the *Langenbeck* instrument. The presenting surface of the dura was smooth, but it bulged and did not pulsate. The arch of the sixth cervical vertebra was next divided on both sides with the laminectome after the spinous processes of the 6th and 5th cervical vertebræ were removed with the rongeur forceps. The arch of the 6th cervical vertebra was easily lifted out with the forceps. A considerable hemorrhage from the bone was arrested by gauze packing. The length of the opening in the vertebral canal was 48 mm. The dura did not pulsate as yet; it appeared under much tension and widened and a body of bluish-red color was shimmering through it. There was distinct fluctuation that evidently was caused by a collection of liquor cerebro-spinalis.

A small incision was now made into the middle of the dura, from which clear cerebro-spinal fluid was ejected in spurts synchronous with the pulsations. At this point the tumor appeared in the opening. After enlarging the incision to a length of about 42 mm., a smooth, violet-colored, jellylike tumor of about the shape of a date was found underneath the dura, posteriorly and a little to the right. The sharply circumscribed upper end of the tumor, which was entirely encapsulated, corresponded to about the middle of the arch of the 6th vertebra. It was situated between the dura and medulla spinalis (see Plate L, Fig. a). It disappeared below the arch of the 1st thoracic vertebra. Upon grasping its upper end with the thumb forceps it could easily be detached from the spinal cord, and a four-tailed posterior nerve root was now seen to run into it; this was divided (see Plate L, Fig. b). Slight traction now brought the lower end into view so that the tumor could be lifted out *in toto*. In the fresh state its total length was 34 mm.; its width 16 mm., and its thickness 7 mm. The change in color of the neoplasm immediately upon its removal was striking. While *in situ* it was of a violet color, a short time after its removal it assumed a liver-brown hue. Macroscopically it was diagnosed as a fibromyxoma. The microscopic examination proved it to be a fibroma, rich in cellular elements and œdematous infiltration. The compression of the cord did not appear to have been severe, and the bed of the tumor was represented by a slight depression, which did not bleed.

The dura was closed by two sutures of linen and the musculature united in two layers with the same suture material, while the skin was closed with silk. The entire operation lasted a little less than an hour, and no vessels had to be ligated.

Three days later the subjective condition of the patient and his appearance were good. He urinated spontaneously. The pupils and palpebral fissures were narrow, the right somewhat more affected than the left. The hypertonia of the extremities was not as marked, but the tendon phenomena were still exaggerated. Ankle-clonus was marked on the right; on the left slight. On the right *Babinski* but no *Oppenheim.* On the left no *Babinski.* The patient was now able to slightly contract his right quadriceps. He felt contacts on the entire right lower extremity, not on the left. Pricks with the needle were perceived all over the right lower limb, not as a painful sensation but as cold. On the left side also an uncertain sense of cold was perceived by the patient. On the right lower extremity hot and cold were felt as cold; on the left, hot was occasionally perceived as warm, yet interchanges were frequent. Bathyanæsthesia was present on the right side but no longer on the left.

The movements of the right shoulder as well as flexion of the elbow were free, and the contraction of the triceps was somewhat stronger than before the operation. The disturbances of function of the hands and fingers showed no changes. The movements of the left shoulder could be executed, but with considerably less power, especially adduction of the arm. The left forearm could be flexed strongly, but not extended. The movements of the hands were weaker than before the operation. The extensor digitorum communis, the interossei and lumbricales were paralyzed, and the long flexor of the fingers was extremely weak. The tactile anæsthesia at the ulnar border of the right forearm was considerably regressing, while the analgesia persisted.

On the 22d of June incontinence of urine set in. The muscle tonus of the lower extremities had somewhat decreased. The reflexes showed no changes, but on the left side *Babinski* set in again. The patient was able to make tense his right quadriceps as well as the inward rotators of the lower extremity. There were no changes in the tactile sense of the lower extremities. While the analgesia in the left lower extremity continued, pricks with the needle were perceived painful to a slight degree in the right foot and in the lower portion of the leg. The œdema of the lower extremities had disappeared.

The abdominal reflexes were present on both sides.

The triceps of the right arm was fairly strong; the extensor digitorum communis regained its function almost completely. With the exception of the index finger the patient was able to bring his finger-tips to the vola manus. The condition of the left arm was unchanged. Tactile anæsthesia in the ulnar region of the right arm and forearm became almost normal to contacts with the brush. It remained the same on the fingers and hand. For pricks with the needle the conditions were very irregular, viz., in the lower fourth of the forearm and in the arm they were perceived as painful, not so in the other parts of the ulnar side. On the left side the conditions were the same as before the operation, but the analgesia had now also progressed to the radial portion of the hand and fingers.

The pupils and palpebral fissures were contracted on the left somewhat more than on the right side.

At the change of dressings it was found that the lowermost layers of gauze were saturated with cerebro-spinal liquor.

On the 24th of June the patient was able to move the toes of his right foot. He complained of pains in both lower extremities, which were subdued to a considerable degree by the use of pyramidon (0.5 t. i. d.). The temperature rose only once on the day after the operation to 39.2° C., and the pulse to 104 beats per minute; the temperature was generally 37.5° C. and the pulse 90. On the 25th of June the patient was able to move all fingers of the left hand, and on the 27th he complained of drawing pains that changed in intensity; they were radiating from the knees to the foot. In the last few days he again had the sensation of urinary tenesmus. Paræsthesias did not exist. The rigidity in the right lower extremity was no longer considerable, and ankle-clonus could be elicited on both sides. The knee phenomenon was of usual strength and *Babinski* was distinct on the right side, but on the left not at all. *Oppenheim* only on the right to a slight degree.

The patient was able to rotate inward and adduct his right lower extremity, but he could not rotate it outward. He was also able to extend his leg with considerable power while flexion was still absent. He was able to execute slight plantar flexion and movements of the toes. The left thigh was in the same condition as the right, especially the quadriceps, while the left foot and toes were still immobile. Forcible contacts with the brush were not perceived in only a few places of the right thigh. The differentiation between brush and pressure could not as yet be made; in this respect both lower extremities were the same. There existed analgesia of the right thigh and leg to the lowest part of the latter and the foot where pricks with the needle were perceived as painful. On the left lower extremity pricks were painful all over. The patient already noticed passive movements of the big toe, but he was as yet unable to distinguish the direction of the movements. Heat was still perceived as cold in the right lower extremity, and in the left, thermic differences were named correctly.

The tendon phenomena of the right arm were absent. The power of the right triceps and the flexors of the hand had increased. The extensor digitorum communis did also respond to the will of the patient. Extension of the middle and terminal phalanges as well as separation and adduction of the fingers, although incomplete, were now possible. Extension and hyperextension of the thumb were now executed with considerable power, and the patient was able to snap his fingers almost completely into the palm of his hand. The paresis of the left hand had also improved—a moderate flexion of the fingers was possible. Movements of extension were only possible in the thumb and index finger. The region of analgesia at the right upper extremity had meanwhile considerably decreased in extent, i.e., to a place in the median region of the ulnar side of the forearm.

On the 29th of June the patient was able to elevate the left lower extremity, and four days later both lower limbs. On the 2d of July he complained of radiating pains in the left lower limb. On the 4th of July the wound of the operation was healed. The patient complained of a painful sensation of pressure in the region of the mons veneris and the inguinal regions, that was accompanied with a heavy feeling in the knees. These manifestations continued during the night and lasted fourteen hours. The muscle-tonus of the lower extremities was unchanged. The manifestations fluctuated in so far that the *Babinski* and *Oppenheim* phenomena, which had already disappeared, recurred again. The active movements of the right lower extremity consisted of extensive outward rotation, slight inward rotation and fairly powerful extension of the leg; its flexion was impossible. Extension of the toes was a little more extensive than before the operation, and the tibialis anticus could be made tense with considerable power. Especially strong was the plantar flexion of the foot. The patient was able to contract with some power the adductors and the inward rotators of the left lower extremity, and with greater power the quadriceps. Flexion of the left leg was still impossible, and the movements of the toes very weak.

The knee phenomena existed on both sides, and there were also tremors of the feet, *Babinski* and *Oppenheim*. The cremaster reflex was more distinct on the right than on the left side. The reflex of the abdominal walls could be elicited on both sides. Contacts with the brush were perceived on the entire right side, while on the left only in places, and on the abdomen it was perceived with the exception of its lower section. Heat and cold were still perceived in the right lower extremity, with uncertainty especially in the leg, yet in many places the differentiation was distinct. In the left leg this was also felt with uncertainty, but in the thigh it was normal. Pricks with the needle were perceived on both sides well. The differentiation between contacts and pricks was distinct only in certain places. Another examination after the lapse of a quarter of an hour showed the active movements of the lower extremities more powerful. The ability to move the right arm had also considerably improved in all muscle groups. The claw position was barely noticeable. In the previously paralyzed muscle groups only a slight weakness was demonstrable. The tactile anæsthesia was limited to a small area in the ulnar region of the right hand. Pricks were perceived all over the right arm. The weakness of the left triceps was marked, and there still existed a total paralysis of the interossei and lumbricales. The flexors of the hand were also very weak, but the hand could, nevertheless, be clenched into a fist, except that the 2d and 3d fingers could not reach the hollow of the hand. The sense of pain was absent on the ball of the small finger as well as on the 4th and 5th fingers. The sense of position was absent on both sides on the three outer fingers. Both pupils and palpebral fissures were narrow, and on the left more contracted than on the right.

On the 8th of July the patient stood up for half an hour for the first time. On the following day the pains had disappeared to a considerable degree, and in the lower extremities they had already disappeared for the last three days. In the feet, however, they were present to a slight degree. There were some gastric disturbances which did not depend upon food; these, however, disappeared about the 11th of July. The 12th of July was the first day on which the patient did not complain of any pain whatever in the feet. With the exception of the 4th finger, which remained somewhat behind in its movements, all the others of the left hand could be completely extended. The patient got up every day; he enjoyed this very much. With the exception of the weakness and tensions that were manifest when the patient was moving his lower extremities, he felt perfectly free from subjective trouble. He was discharged from the sanitarium on the 22d of July, 1907.

On the 22d of August, 1907, he was able to walk when supported on both sides, but with difficulty. His gait was spastic-paretic. At the same time his sexual functions reappeared. On the 13th of September the patient was able, when supported on the arm of a nurse, to walk through the room and to stand up for a moment alone. His walk was the typical cocks-tread gait, and on the left side a distinct paresis of the peroneal group was demonstrable. On the 17th of September, 1907, the patient departed for St. Petersburg. On New Year's, 1909, he sent us compliments of the season, with a letter in which he informed us of his complete restoration to health which had then persisted about a year. He works in the factory as if never ill before, and he undertakes walks of over ten kilometres without excessive fatigue.

In this instance, as in Observation XIII, 1, the first symptom consisted of pains which were at first perceived in the right arm. Under considerable fluctuations this formed the only clinical manifestation for a period of a year. To this a weakness was added which was limited to the same arm for quite a considerable period until both symptoms appeared in the left upper extremity. After many months the legs, especially the right one, became affected with weakness and rigidity. With the increasing paralytic manifestations and the appearance of urinary disturbances, the pains became milder. We were, therefore, dealing with a compression of the lower portion of the cervical cord on the right side. The muscles supplied by the 8th cervical and 1st dorsal roots were affected, and of these, principally the triceps, the long flexor of the fingers, muscles of the thumb and small muscles of the hand. The electric irritability was only slightly changed. The sensory disturbances were limited to these two root regions and 7th cervical root. These clinical manifestations were soon accompanied with oculo-pupillary symptoms, and with signs of interrupted conduction in the form of spastic paralysis of the lower extremities, disturbances of the bladder and a loss of sensation as high as the 2d or the 3d rib. This case may be looked upon as a typical one, since it was possible to make a diagnosis of the disease and to exactly ascertain the level of the site of the morbid focus. *H. Oppenheim* was therefore in a position to recommend operative treatment.

The motor ataxia observed after the operation is noteworthy. I shall speak of it again in the chapter on *"Course After Laminectomy"* (p. 1133). *Oppenheim* and myself have described similar manifestations in the previously quoted case (Observation XIII, 2). In this instance the ataxia disappeared first in the lower extremities, while later on it could still be distinctly demonstrated in the hands for quite a period.

OBSERVATION XIII, 4

Myxosarcoma of the Arachnoid at the Level of the Arches of the Fourth to Seventh Cervical Vertebræ. Extirpation. Death from Exhaustion Two Days Later.

This observation is fully published by *H. Oppenheim* in "Beiträge zur Diagnostik und Therapie der Geschwülste im Bereich des centralen Nervensystems," Berlin, 1907, pp. 135-146.

Mr. M. G., forty years of age, became ill in January, 1903, with pains in the upper spinal vertebræ, which radiated to both hands, especially to the left. To this was added rigidity in the back, paræsthesias in the left hand, accompanied with a sense of weakness and astereognosis, which were less marked in the right hand. There was also a weakness in the left lower extremity with exaggerated tendon phenomena, and later on a sense of warmth and anæsthesia in the right lower extremity, and above the anæsthetic zone, girdle sensation and slight hyperæsthesia, and finally weakness of the bladder. On the 23d of April, 1904, while the patient was in Switzerland, the 5th and 6th cervical vertebræ were there trephined, **the dura, however, was not opened,** and no tumor was found. Healing progressed without disturbances. On the 27th of May a complete spastic paraplegia and paralysis of both arms set in, and there also existed a general hypæsthesia that extended to the 3d or 2d rib.

On the 7th of January, 1905, the arms had somewhat improved, and on the 27th of June, 1906, the patient was able to move his right lower extremity to a limited extent, and the functions of the bladder were practically good. After that an aggravation of the general condition of the patient set in again, the lower extremities became paralyzed and contracted, and finally the upper extremities became similarly involved. On the 28th of July, 1906, the patient was examined by *His Excellency Erb, Professors Oppenheim* and *Schönborn* in Heidelberg. For an exact description of the findings I refer the reader to *Oppenheim's* original report. The result of this and subsequent examinations he concluded on the 30th of August, 1906, as follows:

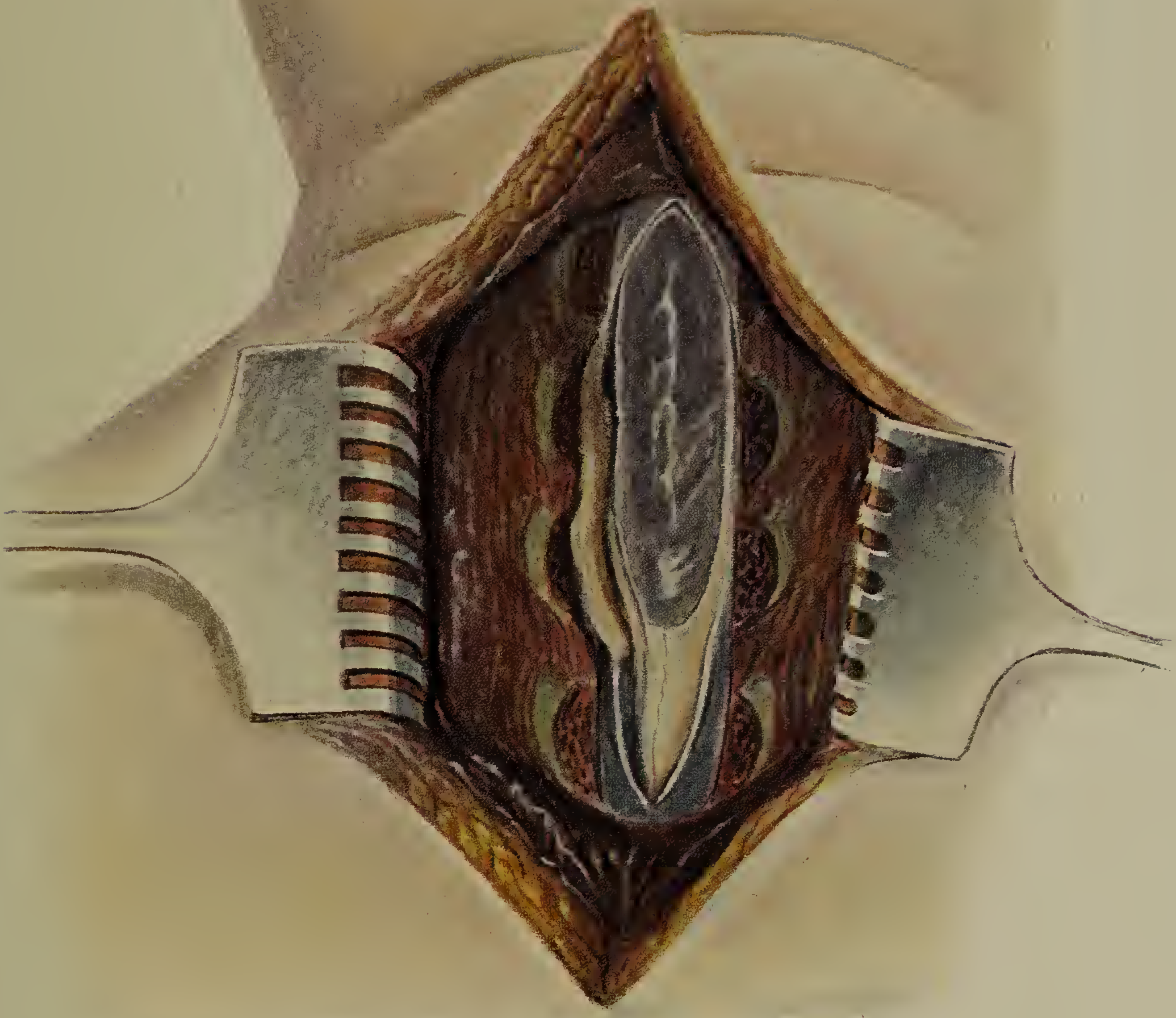

Fig. a.

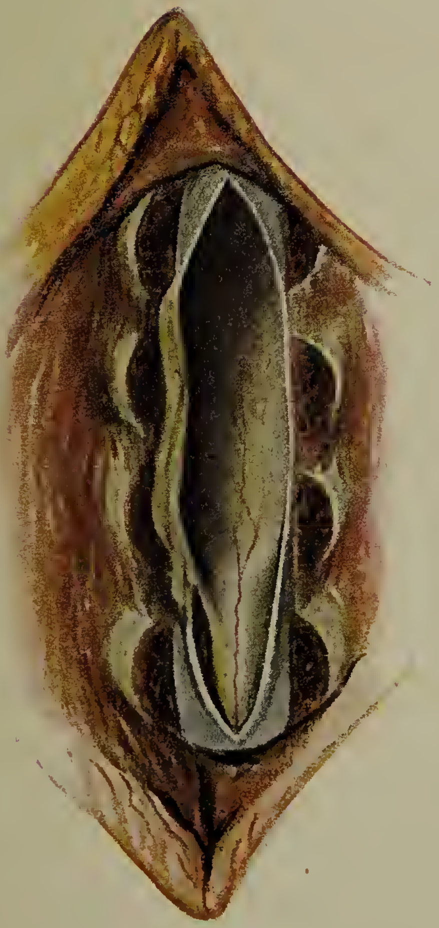

Fig. b.

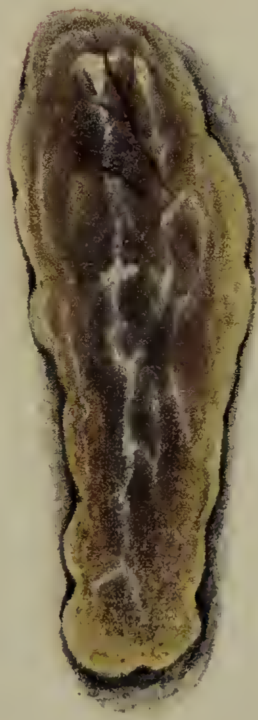

Fig. c. (Scale $^1/_1$)

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"The symptomatology points to a morbid process that extends to the lower median portion of the cervical cord to a considerable height, and in this situation causes, in the deeper portions, nearly a total interruption of conduction in the longitudinal tracts, while it exercises its influences on the cord and its nerve roots in an upward direction in a successive and leaping manner. For instance, some of the muscles supplied by the 7th cervical roots (VIIth segment), as the extensors of the hand and the extensor communis digitorum remained entirely unaffected, while those supplied from the Vth and VIth cervicals were greatly interfered with. Furthermore, the upper limit of the anæsthesia pointed to a higher position of the process, or a higher extension of the motor disturbances respectively.

"The gradual progressive development and the absence of any systematization points in the first place to a **neoplasm.** The fact that the morbid focus possesses quite a vertical extent and that it follows neither the longitudinal tracts nor does it possess disseminated nature, also speaks for a tumorlike process.

"The main difficulty lies in the decision whether the tumor is intra- or extra-medullary, whether we are dealing with a glioma medullæ spinalis (gliosis improbable) or whether the case is one of meningeal tumor. And it should be stated at the outset that such a **decision cannot be reached with perfect accuracy.**

"The following speaks for an extramedullary process.

"1. The slow development of *Brown-Séquard's* symptoms and the long persistence of this stage. (This, however, occurs exceptionally in cases of intramedullary tumor.)

"2. The marked development of the spastic symptoms and the increased reflex irritability of the extremities. (Occurs also occasionally in intramedullary neoplasm.)

"3. The fact that the interruption of conduction in the long tracts was almost complete, while nuclear or nucleo-radicular symptoms were only slightly developed. (Complete absence of degenerative paralysis.)

"A glioma could explain this symptomatology only, if it had a broad base in the lower cervical (eventually upper dorsal) portion of the cord and consequently decreasing in size in an upward direction would disappear in irregular broadening. That this is the case is hard to imagine. In extramedullary tumors this mode of compression is not uncommon: strong, increasing pressure at the lower pole or in the middle, slighter and less stable at the upper pole. There may also be an increasing injury of the white substance from compression and longer resistance of the gray matter and roots.

"The case is by no means typical and presents many unusual facts and certain indistinctness. For example:

"1. The absence of, or only slight pain.

"2. The slight muscular atrophy and the electrical changes —but this is occasionally observed in very protracted compression of the gray substance (anterior roots).

"3. The absence of a distinct upper limit and the absence of harmony between the disturbances of motility and sensation of the upper extremities. However, it is hard to tell in how far the first operation is responsible for the existing conditions.

"4. The manifestation that in spite of the beginning of the trouble on the left side the right hand is now mainly affected. Here also the operation may have something to do with it (pressure against bone).

"5. The fluctuations in the course of the disease and the intercurrent improvement. This also occurs exceptionally in instances of extramedullary tumor.

"Taking all in all, an assumption of an **extramedullary tumor** (eventually of a pachymeningitis cervicalis hypertrophica) offers a somewhat greater probability. I, therefore, believe an **exploratory laminectomy at the level of the 6th and 7th cervical vertebrae** to be indicated, and opening of the dura justified."

The operation was performed on the 6th of September, 1906, with the patient in the right lateral-abdominal position and under the influence of chloroform-ogygen narcosis. A longitudinal incision through the old scar exposed the spinous processes of the 5th cervical to the 1st dorsal vertebra. The musculature was next separated from both sides with a raspatory. Careful investigation showed that the arches of the 6th and 7th cervical and the spinous process of the 1st thoracic vertebra were removed at the first operation. The exposed portion of the dura in this cleft was covered with an indurated, thickened scar. There were no visible pulsations of the dura, but the number of pulse-beats could be distinctly counted through the liquor with the finger.

In order to expose the dura in a region not altered, the perfectly normal arch of the 1st thoracic vertebra was drilled on both sides with a burr and the division completed with the laminectome introduced into the drilled holes. This exposed the bluish-white sac of dura. The remnants of the arches of the 6th and 7th vertebræ were then removed with the rongeur forceps as far as their junction with the bodies of the vertebræ. The dura was incised longitudinally at a point corresponding to the arch of the removed 1st thoracic vertebra. A moderate quantity of liquor now drained away—not in a jet. Separation of the borders of the incised dura showed that it was inseparably united to the scar of the previous operation and to the spinal cord itself. A continuation of the incision of dura upward was therefore not permissible, but it was enlarged on the right and left side where the dura was normal on either side of the old scar. By this means injury to the cord was avoided. Fig. a, on Plate LI, shows the induration on the left.

This procedure exposed a dark-blue tumor of fairly smooth surface which in places presented a glassy appearance. The caudal end of the tumor could be easily removed from the cord—it corresponded to the arch of the 7th cervical vertebra. The detachment of the dura upward succeeded only after the tearing of a few fibres of the roots which the tumor had embraced in its growth. To reach the upper end of the neoplasm, it was necessary to remove the arch of the 5th cervical vertebra, and the dura, which in this situation was normal, was split lengthwise in the median line. The neoplasm extended about ½ cm. more upward under the arch of the 4th cervical vertebra. It could be enucleated from its smooth envelope without sacrificing the bone. It was immediately connected with the arachnoid and, after tearing a few fibres, it was easily detached from the pia and cord. Two posterior root-fibres penetrated the tumor and had to be divided. While this was being done, twitchings of the arms set in and, while the upper end of the tumor-mass was pulled forward, the respirations ceased temporarily (action on the phrenic).

The tumor (Plate LI, Fig. c) was 73 mm. long and at its widest upper portion measured 23 mm. in width. It was soft in consistency, bluish in color and had a glassy, œdematous appearance. Its width completely filled the vertebral canal. Its position was somewhat to the left. After its enucleation a deep trough remained behind (compare Plate LI, Fig. b) which did not flatten out as long as the cord remained visible. The normal dura was united at the upper angle of the wound with one and in the lower with two sutures. In the middle, where the induration was excised, no suture could be introduced. Over this the muscles and skin were united. The length of the incision of the skin was 14 cm.

The course of the disease after the difficult operation, that lasted one hour and three-quarters, was at first satisfactory.

The patient recuperated and on the following day the danger of collapse had evidently passed, and no blood nor liquor had saturated the dressings. On the night between the second and third day, however, the heart of the patient, who was a sufferer for years and whose condition was complicated by cystitis and furunculosis, refused action and on the morning of the 8th of September—forty-five hours after the operation—he died with convulsions of the left side of the body. The post-mortem examination showed in the dorsal half of the spinal cord in the region of the cervical enlargement from about its upper third downward, a decided flattening that measured from above downward about 80 mm. The pia was present in the entire extent of this flattening and, compared with the pia of the rest of the cord, it was slightly reddened, evidently due to imbibition of blood. The flattened place corresponded to the region where the subdural tumor was located. It was removed *in toto.* At its central end a slight hemorrhage into the pia took place which extended only a few millimetres upward. The dura above and below, corresponding to the insertion of the sutures, was covered with slight blood coagula. The spinal nerve roots on the right side were of normal size, while on the left they were considerably thinned.

Cauda Equina

The portion of the spinal cord offering the greatest difficulty in level diagnosis is the cauda equina, and in this particular region it would have been of greatest value for surgical intervention since it extends over ten intervertebral openings. For instance, the first sacral nerve in the adult runs from its origin to its exit for a distance of 14 cm. within the sac of dura. From the lower border of the body of the first lumbar vertebra, or from the middle of the 2d on, the spinal roots are closely grouped within the vertebral canal, i.e., from the 2d lumbar pair on, all lumbar-, sacral- and coccygeal-roots; those emerging at a higher level are situated laterally, and those lower, medianward. Since, however, the pairs of roots have the same functions as their corresponding spinal segments, the actual segment-symptoms resulting from compression of either the cord or the nerves are not followed by marked differences in the clinical manifestations, be they due to compression of the cauda or their respective sections of the lumbo-sacral cord.

We divide the *epiconus medullaris* which contains the segments of the 4th and 5th lumbar as well as the 1st and 2d pairs of sacral nerve roots from the *conus medullaris* which comprises the three lower sacral and the coccygeal segment. However, clinical experiences in connection with anatomic and operative results have disclosed a few symptoms that may be utilized in diagnosis. I shall cite two personal observations.

OBSERVATION XIII, 5

Enchondroma of the Posterior Surface of the Body of the Third Lumbar Vertebra which had considerably Narrowed the Vertebral Canal. Operation on the 23d of December, 1908. Cure.

This case has been published in the "Deutsche Medizinische Wochenschrift," 1909, No. 16, under the title: "*H. Oppenheim* and *F. Krause,* Über Einklemmung, bzw. Strangulation der Cauda Equina."

A man, forty-three years of age, otherwise well without a history of syphilis, complained for the last three or four years of occasional pains and paræsthesias as well as a certain restriction in the mobility of both lower extremities which were mainly marked after exertions and lively movements. On the 30th of October, 1908, he attempted to prevent the falling of a swaying man by catching him with both arms and supporting him. While doing this he was compelled to bend forward and to use a great deal of power, during which he was dragged for a few steps. Immediately thereafter he perceived a pain in the left lumbar region which became more intense from minute to minute, until after a lapse of half an hour he was unable to stand erect and had to be put to bed. His main complaints now consisted of violent pains in the back at every attempt to change his position, of annoying pulling sensations in the lower extremities, which appeared almost completely paralyzed, and of almost total insensibility of his buttocks. Outside of these symptoms of marked irritation there were other symptoms referable to the plexus-lumbosacralis, in other words a symptom complexus that spoke for an affection of the cauda equina high up.

A part of the morbid manifestations, especially those of irritation, receded under rest and iodides. After this the course of the disease was changeable, but there gradually developed symptoms of degeneration (reaction of degeneration) of the paralyzed parts and which also involved a muscle that up to that time was unaffected (extensor cruris quadriceps sinister). The anæsthesia was changeable in some places and in others (posterior surface of the thigh) it comprised a greater area. These clinical manifestations suggested a space-restricting process, perhaps due to neoplasm. The manifestations referrible to the nervous system pointed to the 3d lumbar vertebra which was sensitive to pressure.

H. Oppenheim referred the patient to me for operation with the following report: " In this patient, manifestations referrible to the region of the sacral roots gradually developed within a few years, being limited mainly to the right side, yet the 5th lumbar and on the left side the 4th were participating. The manifestations consisted of pains located in the lumbo-gluteal region as well as in the region of the sciatic nerves, paræsthesias of the same distribution, which affect the peroneus and tibialis posticus on the right side with almost no involvement of the tibialis anticus, involvement of the same region but to a slighter extent on the left side, and here also incomplete affection of the extensor cruris quadriceps and the glutæi mainly on the right.

These are associated with disturbances of sensation which are mainly marked in the region of the 3d and 4th sacral on the right side (circumanal), to a slight extent in the region of the upper sacral roots and slight disturbances of the functions of the bladder and rectum.

"The condition may have originated from the lumbo-sacral cord (conus and epiconus) or from the cauda equina. The asymmetry, the pains, the slight accentuation of disturbances of the sphincters, the non-participation of the upper lumbar roots, renders the origin of the morbid process from the spinal cord improbable. I am inclined to believe that the morbid condition is situated in the upper region of the cauda equina about the level of the 3d lumbar vertebra mainly to the right. Of course, it may extend somewhat above this point or somewhat lower. Since there is nothing in the clinical history that speaks for syphilis (*Wassermann* negative), a neoplasm or a similar process (vascular tumor (?), meningitis serosa (?)), which exercises compression, are to be taken into consideration.

"Internal medication proving of no avail, I am for laminectomy at first at the level of the 3d lumbar vertebra."

On the 23d of December, 1908, the patient was operated on, and since the symptoms in correspondence with the focal manifestations pointed to the right side, the patient was placed somewhat toward the left. The thighs were semiflexed in the hip- and knee-joints in order to render the lumbar portion of the vertebral column prominent. The back in the lumbar region was made as prominent as possible for the same reason. In order to avoid evil influences of compression on the heart and region of the chest, the pelvis was made to rest on a heavy cushion while the shoulders were resting on the operating table. The extremities were wrapped in thick flannel blankets and the chest and abdomen were also covered with flannel.

After making a longitudinal incision the 2d, 3d, and 4th arches of the lumbar vertebræ were exposed. After removing the 2d and 3d arches, the dura lay exposed to an extent of 6 cm. It did not pulsate at all, and in its upper two-thirds it was seen to be tense on account of the accumulation of liquor, while in its lower portion the tension was evidently due to the presence of a solid mass. An opening made into the dura brought forth a gush of liquor, and with it the closely set roots of the cauda equina projected from the opening of the dura like a hernia, so that the impression was gained that the pressure must have been great (Fig. 170). The dura was split longitudinally to the entire length of the wound, and after the cauda equina was lifted upward with a pair of blunt hooks a tumor twice the size of a bean of longitudinal direction situated in the lower portion of the wound came to view (see Fig. 171, below). It was covered by normal dura from the posterior surface of the bodies of the vertebræ. The neoplasm was of solid consistency. To eliminate the possibility of a vascular tumor it was aspirated. Since no blood came away, an attempt was made to separate the dura from the tumor with an elevator, i.e., from the posterior surface of the

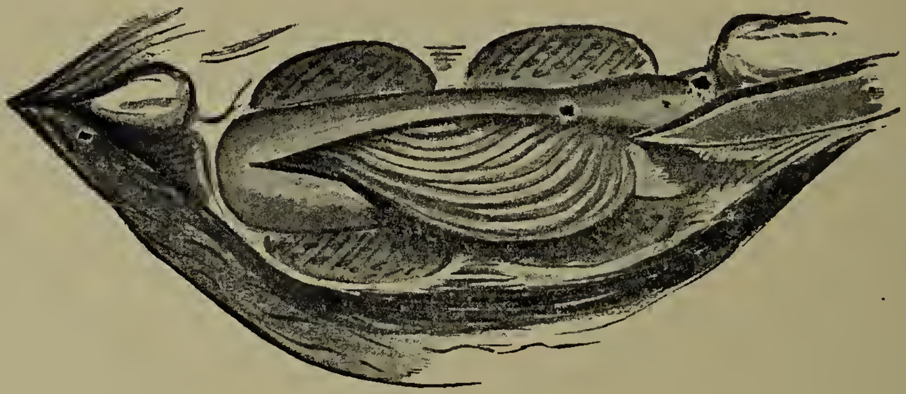

Fig. 170

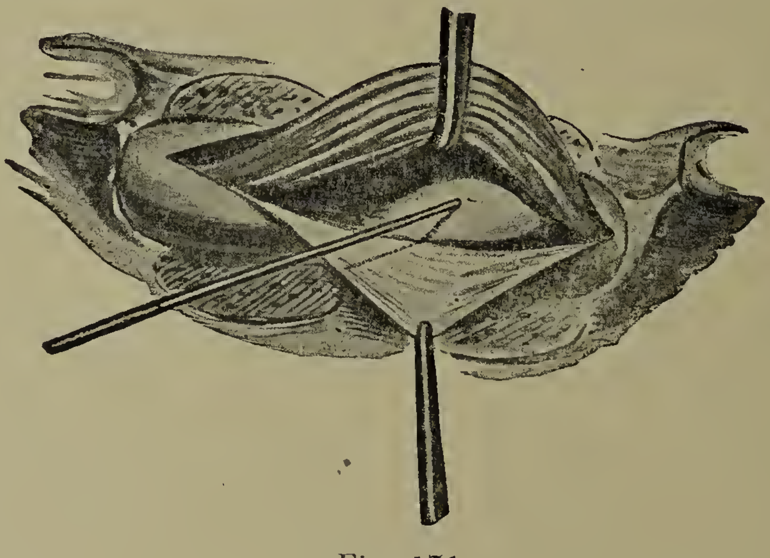

Fig. 171
Extradural Enchondroma

bodies of the vertebræ; this, however, was not successful on account of the very close union. A longitudinal incision was therefore made into the anterior surface of the dura above the highest level of the tumor, and the latter was removed as radically as possible by means of a sharp spoon. During this step of the operation there was a considerable hemorrhage. Intradural probing showed a region that was free for about the length of a finger downward, and a similar region above, that extended for at least two vertebral arches. Suture of the dura and wound.

Microscopic examination of the extirpated tumor-masses (*Chief Physician Dr. Heymann*) showed it to consist mainly of cartilage tissue with few cartilage-cells. The fibrous elements were fairly strong and bloodvessels extremely few. In only a few places aggregations of granulation-cells were present. No necrosis. Few calcified places. No bone tissue.

The operation was very successful and the pains and paræsthesias ceased at once even while the patient was sneezing or coughing, and there was improvement in all morbid manifestations. This improvement of the patient was delayed for a period of at least two weeks by a cystitis which was accompanied by fever. After this the patient was able to attempt standing and walking. Four months after the operation he informed me in a letter that he was able to walk a few steps in his room or on the street without any support. With the aid of two canes he was able to walk for twenty minutes without becoming especially fatigued. Six months later—about ten months after the operation—his general condition was very much improved; he was able to walk two thousand steps without a cane, and when supported with a cane he could continue for an hour and a half. Without it he was able to ascend stairs with difficulty, with it he could do so with ease. Of the right-sided paralysis of the peroneal group there was only a slight remnant. When the patient was sitting he was able to execute dorsal flexion with the right foot to a normal degree while plantar flexion only to a right angle. Pronation and supination were not possible. The patient was able to accomplish all movements with the left foot. His general condition was good.

The neoplasm was situated, as diagnosed by *H. Oppenheim*, at the level of the 3d lumbar vertebra and affected therefore only the cauda equina. Characteristic of this position were the sensory manifestations of irritation in the form of pains in the perineum and anus and in the region of the sciatic nerves. These were associated with paræsthesias in the same region and anæsthesias in the region of the 3d and 4th sacral (circumanal) and less marked in the upper sacral roots. The functions of the bladder and rectum had also suffered. There was finally an asymmetric participation of the musculature which produced flaccid paralysis. While the peroneus and tibialis posticus (L_5S_1), leaving out the tibialis anticus (L_4) of the right side, were more affected, the left quadriceps (L_2 and $_3$), and on the right side the gluteal muscles (L_4 and $_5$), were affected sympathetically.

With participation of the conus medullaris the functions of the genitals, bladder, and rectum, as well as an anæsthesia in the region of the anus, perineum, and the genitals could be produced, as was the case in this instance. In diseases of the conus, sensory symptoms of irritation are usually absent, while in our case they were present. Tumors exercising pressure on the cord cause, as a rule, at first unilateral root symptoms, because the roots of the other side are protected to a certain measure by the spinal cord itself. Contrary to this, however, as in our case, diseases of the cauda will not infrequently cause manifestations that are bilateral from the beginning. Again, diseases of the conus produce motor disturbances that follow the arrangement of the segments, while in our case they were asymmetric.

With reference to the level, the upper lumbar roots were free, which spoke against the participation of the lumbo-sacral cord. The disturbances had to be located so high that the uppermost roots were reached at their points of exit. This corresponded to the third lumbar vertebra at the upper limit of which the 2d and at the lower the 3d pairs of lumbar roots emerged from the vertebral canal.

I shall describe an intradural neoplasm in the form of an exostosis in the chapter on "*Meningitis Serosa Chronica*" (Observation XIV, 5, p. 1071).

Especially difficult for diagnosis as well as for operation are those cases in which the cauda equina and the upper sacral or the lower lumbar cord are simultaneously affected. A personal observation of such a case follows.

OBSERVATION XIII, 6

Angiosarcoma of the Soft Membranes of the Spinal Cord in the Region of its Lumbar and Sacral Portions as Well as in the Cauda Equina. Death in Collapse, Twelve Hours After Incompleted Operation.

The patient in this case was a woman, twenty-four years of age, who was referred, on the 12th of December, 1901, to the Augusta Hospital by *Professor Remak.* He placed the following history at our disposal.

Two years prior to her admission, the patient fell backward from a flight of stairs and forcibly struck the ground with her back and sacrum. Six months later she began to complain of pains in the sacrum. She could not sit for any length of time. In the beginning of 1901 the pains became stronger and the patient began to limp on the left foot; she then consulted a physician. At that time a diagnosis of sciatica was made. Steam-baths, sweating, electricity, etc., were tried but without success, and the walk of the patient became worse from day to day. On the 16th of May, 1901, the patient had to be catheterized for the first time. From then on, her menstruation, which was always regular, ceased, her walk became almost impossible and the pains worse.

At the first examination (October, 1901) the findings of *Remak* were as follows: The patient could walk into the room supported, but she had to be carried up the stairs. Her gait was peculiar. She projected her buttocks to a striking degree, but permitted the point of the left foot to drag. Careful examination showed a paresis or paralysis in the region of the left gluteal muscles; their faradic irritability was gone. There was also a partial paralysis of the peroneus on the left side which was mainly located, by electric examination, in the tibialis anticus. Reaction of degeneration was not present in the glutei nor in the region of the peroneus.

The enormous sensitiveness to pressure rendered the examination very difficult, and all that could be elicited was that both patellar reflexes were gone without the existence of manifestations of paralysis of the extensors of the thigh. On the left leg a slight hypæsthesia dolorosa could be demonstrated. There were also transitory disturbances of the bladder.

The relatives of the patient did not consent to an immediate operation. The manifestations, however, became so much aggravated that two months later the parents of the patient brought her to the Augusta Hospital for operation. At that time it was impossible for her to walk.

About the middle of December, 1901, her condition was as follows: She was well nourished and very obese. Her heart, lungs and kidneys were negative, and the pulse was frequent and of variable intensity. No deformity was discovered on the vertebral column, and there were neither œdema nor infiltration in any portion of its soft parts. There was a high degree of sensitiveness to pressure between the spinous processes of the 4th and 5th lumbar vertebræ and also pain on percussion. The entire sacrum was extremely painful to pressure and the pains radiated to the region of the trochanters and down to the legs. Every change of position was accompanied by loud crying of the patient. There was a changeable sensitiveness to pressure of the upper lumbar and lower thoracic vertebræ.

The rectal examination without an anæsthetic was very painful and, with the patient asleep, disclosed no abnormalities. Upon introduction of the finger normal contractions of the sphincters were perceived. The functions of the bladder and rectum were somewhat retarded, but there existed no incontinence.

The patellar reflexes could not be elicited. The left foot hung down in a pes equinus fashion and the left thigh lay rotated inward. There was no atrophy of the left leg and the circumference of the calf was 27 cm. on both sides. The musculature of the left quadriceps and calf felt somewhat flaccid on this side, however. The function of the left quadriceps was incomplete; active extension of the flexed leg at the knee was hardly possible on the left side, while on the right it was executed fairly well. The left ileopsoas was weaker than the right. On the left side there was a complete paralysis of the peroneus, the joints of the toes were in plantar flexion while on the right side they were flexed dorsally. The function of the extensors of the feet was extremely slight, and the power of the musculature of

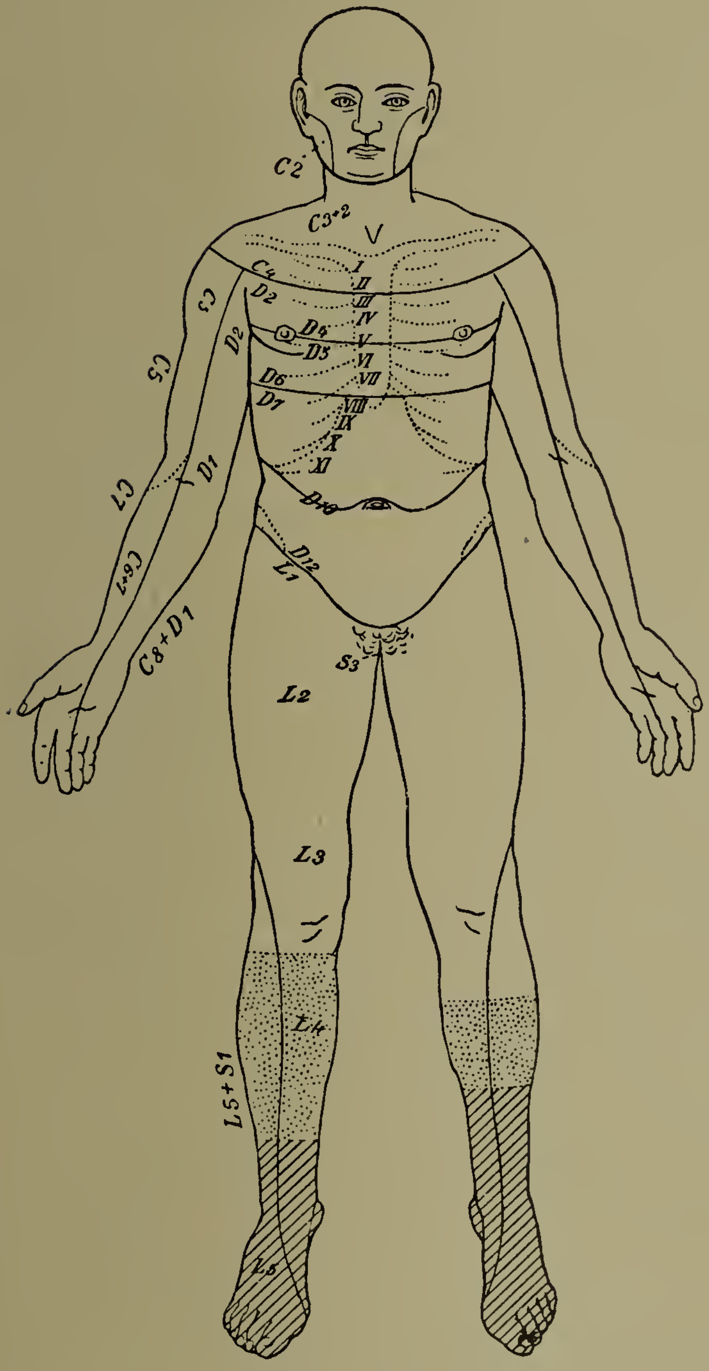

Fig. 172

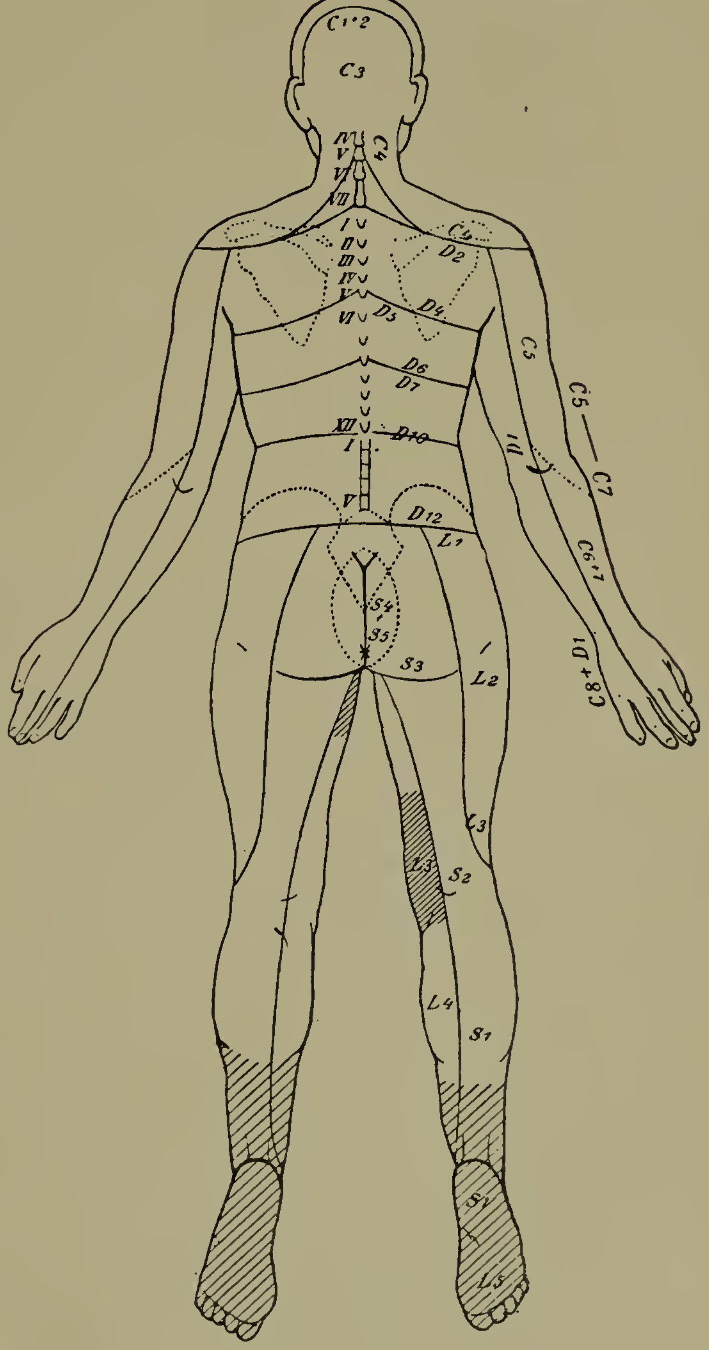

Fig. 173

▨ Decreased Sensibility

░ Hyperæsthesia

the calf of the left side (contra-pressure against the hand) was executed fairly but weaker than on the right side. The flexors of the left leg were functionating. The musculature of the left buttock (outward rotators) was atrophic. There was a motor weakness in the right lower extremity, but the function of the extensors was good. Percussion of the patellar tendon was not followed by contraction of the quadriceps but of the adductors on both sides. When the patient was asked to elevate her lower extremities, a distinct ataxia was discovered.

The electric examination, with the patient under the influence of an anæsthetic, showed the following: On the left side the gluteus maximus muscle and the other outward rotators did not react; the outward rotators reacted on the right side. Irritation of the right nervus peroneus elicited contractions. The irritability of the adductors of both sides was good (nervus obturatorius) and that of the left nervus cruralis was, corresponding to the atrophy of the quadriceps, somewhat reduced. The left tibialis anticus muscle still reacted and showed no reaction of degeneration.

The **sensibility** down to the knees was not disturbed, yet there existed a small zone of reduced sensibility for contacts with the brush and temperature on the inner side of the right thigh (L_3) (Fig. 172, p. 1049). There was also a diminution of sensation in both feet which, however, did not extend to the calves (L_5 and S_1). On the anterior surface of the leg, however, and not extending as high as the knee, a hyperæsthetic zone was found (L_4, $L_5 + S_1$). Localization was frequently erroneous; for instance, in testing the left foot the right shin-bone was projected. Cold and warm were perceived on both calves indistinctly, and cold less so than warm.

The sensory nerve-root regions S_1, $L_{3,\ 4}$ and L_5 were affected; S_2 and S_3 were free. Of the motor-roots of the left side the following were involved: Ileopsoas $L_{1,\ 2,\ 3}$; quadriceps $L_{2,\ 3\ 4}$; tibialis anticus $L_{4,\ 5}$; flexors of the leg L_5; glutei L_5; peronei L_5, S_1. All lumbar and the 1st sacral segment were also involved.

I performed the operation on the 27th of December, 1901, with the patient under the influence of chloroform. After removing the arch of the 4th lumbar vertebra the dura appeared very tense and of a dark-blue color. Extradurally nothing abnormal was found. After removing the arch of the 5th vertebra a smooth newformation of bluish-black color and about the size of a digit projected from below in the median line from the vertebral canal. During the resection of the 1st sacral arch a cavity was torn into, which did not belong to the sac of dura and from which about 10 drops of a yellowish fluid containing needles of cholesterin were evacuated. The cleft in the vertebral canal was 11.3 cm. in size. The tense dura was split which at once exposed the solid intradural tumor. A root was seen running from right to left upward toward the lower pole of the neoplasm. The tumor was very soft in consistency and was detached with the finger from below and the thus loosened portion removed. Its lower end was freely exposed, but its upper limit could, in spite of the removal of the arch of the 3d lumbar vertebra and the opening of the vertebral canal to a length of 14 cm., not be reached. The operation had to be interrupted on account of collapse of the patient. No cerebro-spinal liquor whatever was evacuated. Deep suture of muscles with catgut. Closure of the wound of the skin which measured 24 cm.

The length of the tumor removed was 9 cm.; its greatest width 23 mm. We were dealing with a very soft, gray-red sarcoma. The bleeding during the operation was slight, and only one vessel had to be ligated. The rest of the hemorrhage was controlled by compression. After the operation the pulse was small although not very frequent (84), and the general impression an hour after the operation was satisfactory. In the following hours the condition of the patient became worse, and she died of collapse at eleven o'clock in the evening.

The post-mortem examination (*Professor Dr. Oestreich*) showed only small quantities of blood in the vertebral canal in the region of the operation. The gluteal musculature was brownish, especially on the left side. In some places it was also yellowish-gray and atrophic. After counting the exposed vertebral column it was found that the 3d to the 5th lumbar vertebræ and the upper part of the sacrum were removed. Above the field of operation, as high as the 12th thoracic vertebra, there was a spindle-shaped enlargement of the dura and the spinal cord. (Plate LII, Fig. a.) At the region of this lumbar enlargement the spinal cord and the nerves radiating from it were enlarged, the enlargement increasing in a downward direction. Its consistency was soft and jellylike. The affected nerves were in part yellow and in part gray. The tumor-mass itself was grayish-red, very soft and succulent. Cross section of the upper thoracic cord was not pure white, but the white substance was of a light yellow color. The bloodvessels above the tumor were markedly dilated, tortuous and turgid. A transition from the neoplasm to the vertebral column did not exist. The left ventricle was dilated, the myocardium pale and light-brown. The other organs showed no abnormalities.

Diagnosis.—Angiosarcoma spinale, lumbale et sacrale (the endothelium of the pia showed hyaline degeneration).

According to the above-cited localization of the paralyses, a lesion of the lumbar roots had to be assumed. There were no disturbances of motility and sensibility higher up. On the other hand, there was an excessive sensitiveness to pressure over the sacrum and the intolerable pains radiated from this situation. In the absence of tuberculosis and a negative history of syphilis, the progressive development of the malady had to be diagnosed as one of tumor either in the cauda equina or in the lower portion of the spinal cord itself.

The extraordinary sensitiveness of the sacrum spoke principally for a disease of the cauda, because in these instances the pains are usually excruciating and of great extent. In our case they affected mainly the sacrum and the coccyx. The neoplasm had evidently affected the cauda the least, because the greatest point of sensitiveness was below the 2d lumbar vertebra. While in the beginning of the disease manifestations of irritation in the sensory sphere affected mainly the sacral region and the left lower extremity, in the later course of the malady motor disturbances, especially of the gluteal and peroneal groups, were added. The slight extent of the sensory disturbances during the rapid progress of the affection was striking.

The operation, however, disclosed an extensive neoplasm of the spinal cord as well as of the cauda. The primary seat of the trouble could not be ascertained even at the autopsy.

Multiple Intravertebral Tumors

In general neuro-fibromatosis, neuromata may also be multiple within the vertebral canal. Animal parasites (cysticerci and echinococci) may also develop in a number of places and, as in the brain, solitary tubercle and metastatic tumors as well as gummata may also affect the spinal cord in multiple form.

The diagnosis of multiple focal disease of the spinal cord is only of interest to the surgeon in so far that in the more favorable cases operative intervention is rendered very difficult and in the unfavorable instances interference should not be attempted.

In the majority of cases the diagnosis of the presence of multiple neoplasmata is unfortunately impossible. If the neoplasm has caused a complete interruption of conduction in a particular place, the extensive symptoms of paralyses and anæsthesias will not permit, from the clinical manifestations, to make a diagnosis as to what the condition below the neoplasm is or whether another tumor has developed. In instances where the conduction is not completely abolished but severely damaged, a correct diagnosis in neoplasmata of the thoracic cord is hardly ever possible, and in its cervical and lumbar portions obtainable only under favorable circumstances in how far the neoplasm had sympathetically affected the cord below. Our knowledge in instances of multiple neoplasmata is by far more uncertain. I recall the case observed by *H. Oppenheim* and myself of a man, forty-six years of age, in whom all symptoms pointed to an intravertebral neoplasm in the region of the 8th cervical segment. The disturbances were at first of the *Brown-Séquard* type, but later on developed on both sides. On account of the development of severe disease of the internal organs, operation was advised against. After a few months the

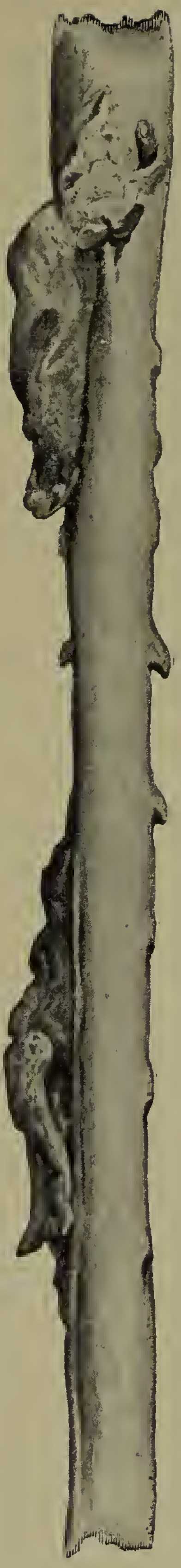

Fig. 174

Two Extradural Sarcomata in a Male Patient Forty-six Years of Age (compare text).

patient died, and the post-mortem examination showed an extradural sarcoma in the region of the arch of the 7th cervical vertebra. Another tumor of the same size and of the same histologic character was also found in the middle portion of the thoracic cord which was also situated extradurally. On account of the high interruption of conduction the tumor situated below produced no new manifestations.

Since the girdle sensation may be perceived lower than the compressing tumor, its occurrence should not lead one to conclude the existence of another neoplasm.

Meningitis Serosa Chronica Circumscripta

Frequently cases come under observation in which the development of the disease as well as the existing clinical manifestations point to a mass compressing the spinal cord in which, however, laminectomy discloses the only or principal cause for the existing disturbances to be a circumscribed collection of liquor cerebro-spinalis under high tension.

When I spoke of the surgical treatment of neoplasmata of the brain and spinal cord at the Congress of Naturalists in Stuttgart in September, 1906, the discussion disclosed that many neurologists expressed surprise at my statements with reference to the class of cases presently considered, and found explanations for a number of hitherto obscure phenomena only after the citation of a series of my personal observations. I based my remarks at that time on the cases observed by *H. Oppenheim* and myself.[1]

Hermann Schlesinger[2] had already described a case of localized hydrops of the spinal membranes with history of the case and post-mortem findings. His paper did not receive much attention, however. A similar case has been reported by *Spiller* and *Musser*[3] which was operated upon by *Edward Martin.* Until the end of July, 1911, I have operated upon forty-five cases for neoplasm of the spinal cord or instances presently considered in which the changes to be described were found eleven times. This, however, may be a casual occurrence in the hands of one observer, but it must be admitted that these cases do not represent exceptional conditions. This view is also held by *Victor Horsley.*[1] Of late a number of publications of this still obscure condition have appeared in the literature.

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[1] *F. Krause,* Zur Kenntnis der Rückenmarkslähmungen. *v. Langenbeck's* "Archiv für Klinische Chirurgie," Vol. LXXXIV. "Verhandlungen der Deutschen Gesellschaft für Chirurgie," XXXVI. Kongress, 1907, p. 598.

H. Oppenheim, "Beiträge zur Diagnostik und Therapie der Geschwülste im Bereich des centralen Nervensystems." Berlin, 1907.

[2] *H. Schlesinger,* "Beiträge zur Kenntnis der Rückenmarks und Wirbeltumoren." Jena, 1898, p. 46.

[3] *Spiller, Musser,* and *Martin,* "University of Pennsylvania Medical Bulletin." March, 1903, Vol. XVI, p. 27.

Spiller, "American Journal of the Medical Sciences," January, 1909, Vol. CXXXVII, p. 95.

Arachnitis Adhaesiva Circumscripta

The development of accumulations of liquor and liquor-tension, limited to a certain circumscribed area of the spinal membranes is remarkable, indeed. *J. Henle*[2] characterizes the arachnoid and subarachnoid tissues as "a physiologically water-thirsty connective tissue of extremely loose make-up. The areolar nature of this tissue permits the fluid to rapidly circulate around the central organ, and the movement of the latter in its watery envelope may actually be compared to a sort of swimming." Since, in the opinion of this author, opening of the fibrous covering of the brain and spinal cord is invariably accompanied by an injury of the arachnoid during which the subarachnoid fluid naturally drains off and the connective tissue collapses, explains why the distinct manifestations observed in the living subject are not found at the post-mortem table. The autopsia in vivo, as surgeons know from experience, frequently furnishes pictures that are physiologically more correct than the necropsy.

"In cases, however," says *Henle,* "where the arachnoid cannot follow, it becomes tense and bridges over the fissures between the convolutions of the brain, the posterior transverse fissure, the posterior lateral fissure and the irregularities at the base of the cerebrum."

According to this author, certain constrictions and closures of individual portions of the central organ occur even in normal subjects, for he says on page 313: "The proximity of the connective tissue trabeculæ and the extent of the areolar spaces of the subarachnoid tissue are in reverse relation to the depth of the valleys over which the arachnoid stretches, and this state of affairs may in places (for instance, in the posterior transverse fissure and between the pons and the hypophysis) show a complete absence of the connections between the arachnoid and the structures underneath it. **In other instances again the areolar tissues condense to a firm partition which divide the subarachnoid space into separate chambers.** Such partitions are frequently seen to extend forward from the corpora candicantia to the arachnoid."

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[1] *Victor Horsley,* Chronic Spinal Meningitis, "British Medical Journal," February 27, 1909, p. 513.

[2] *J. Henle,* "Nervenlehre," I, p. 312.

While *Henle* describes these conditions to exist in the brain, he mentions nothing of their occurrence in the spinal cord. I have, indeed, found such local circumscribed collections of liquor or enclosed œdemæ (hydrops), of the arachnoid spaces in many operations on the brain, especially for epilepsy. With reference to the spinal cord, fluid conditions are quickly rectified under normal conditions, but if pathologic states are present (displacements or adhesions of an inflammatory nature), mechanical changes (*arachnitis adhæsiva circumscripta*) may cause a circumscribed accumulation of liquor to a level of, for instance, two or three vertebral arches.

I have described a case (Observation VII, 3, Vol. II, p. 716) of affection of the cerebellum which was analogous to the just detailed morbid condition of the spinal cord. In that case a cystic tumor resulted from stagnation of liquor that gave rise to manifestations of cerebellar tumor and led to an operation. After the cystlike space was opened into, an extraordinary large quantity of clear liquor was evacuated, while up to that point of the operation not a drop of fluid had drained off. The resemblance of these findings with those of meningitis serosa spinalis impressed my assistants as well as myself, for the reason that this particular morbid picture was observed by us during a number of operations.

Because of our limited knowledge of these processes, I shall at first proceed to cite a few personal observations.

OBSERVATION XIV, 1

Arachnitis Fibrosa with Stagnation of Liquor. Operation March 12, 1906. Four Years Later, Considerable Improvement.

In May, 1901, the patient, who was at that time forty-two years of age, and who was treated seven years before for lues and who was also an alcoholic, was suddenly seized with boring pains in the right half of the chest which radiated from the clavicle downward to about the middle of the sternum. This happened after an exposure to cold while hunting. In the fall the pains became more severe and extended over the entire right side of the chest; this was accompanied by a girdle sensation at the level of the uppermost ribs. Transitory improvements followed various bath-, iodide- and mercury-cures in the following years. Generally, however, the condition became worse in so far that besides an increase and spreading of the pains to the left side the patient also suffered from formications in the soles of the feet, especially of the right, and from asthenia (compare *H. Oppenheim,* "Beiträge zur Diagnostik und Therapie der Geschwülste im Bereich des centralen Nervensystems," Berlin, 1907, Observation 12, p. 151).

The patient was born with a right-sided club-foot which, however, did not interfere with his walking in any manner. Besides this there gradually developed a marked kyphosis of the upper portion of the vertebral column, so that the chin was closely set against the sternum; the kyphosis could, however, be actively straightened out to the full extent.

Where he was treated previously a diagnosis of "metasyphilitic, eccentric neuralgia of the root-zones" was made and a suspicion of tumor entertained. The vertebral canal was opened and the arches of the 2d and 3d dorsal vertebræ removed. Since the dura mater appeared normal and palpation of the cord did not reveal anything of a pathologic nature, the dura was not opened, but the 2d and 4th posterior nerve roots were divided on both sides. The surgeon erred, for without opening the dura mater we can never tell whether intradural changes exist or not. The patient improved only a little and transiently after the operation.

In March, 1906, he was sent to me for operation by *H. Oppenheim,* who diagnosed a probable neoplasm or chronic meningeal inflammation with adhesions at the level of the 2d to the 4th dorsal segment with especial affection of the right half of the spinal cord. In view of the congenital anomaly of the development of the patient (besides right-sided club foot there was also an absence of the 5th metacarpus and a shortening of the 5th finger on the right side), he also thought of a congenital anomaly

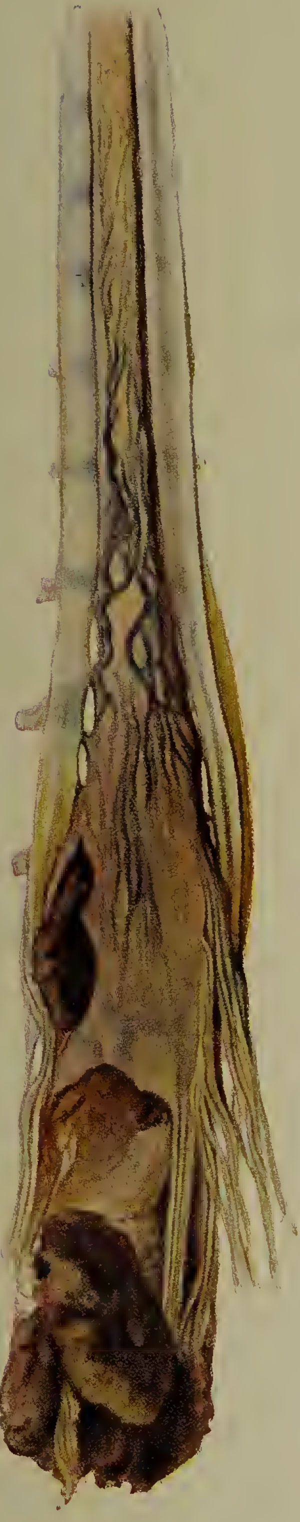

Fig. a.

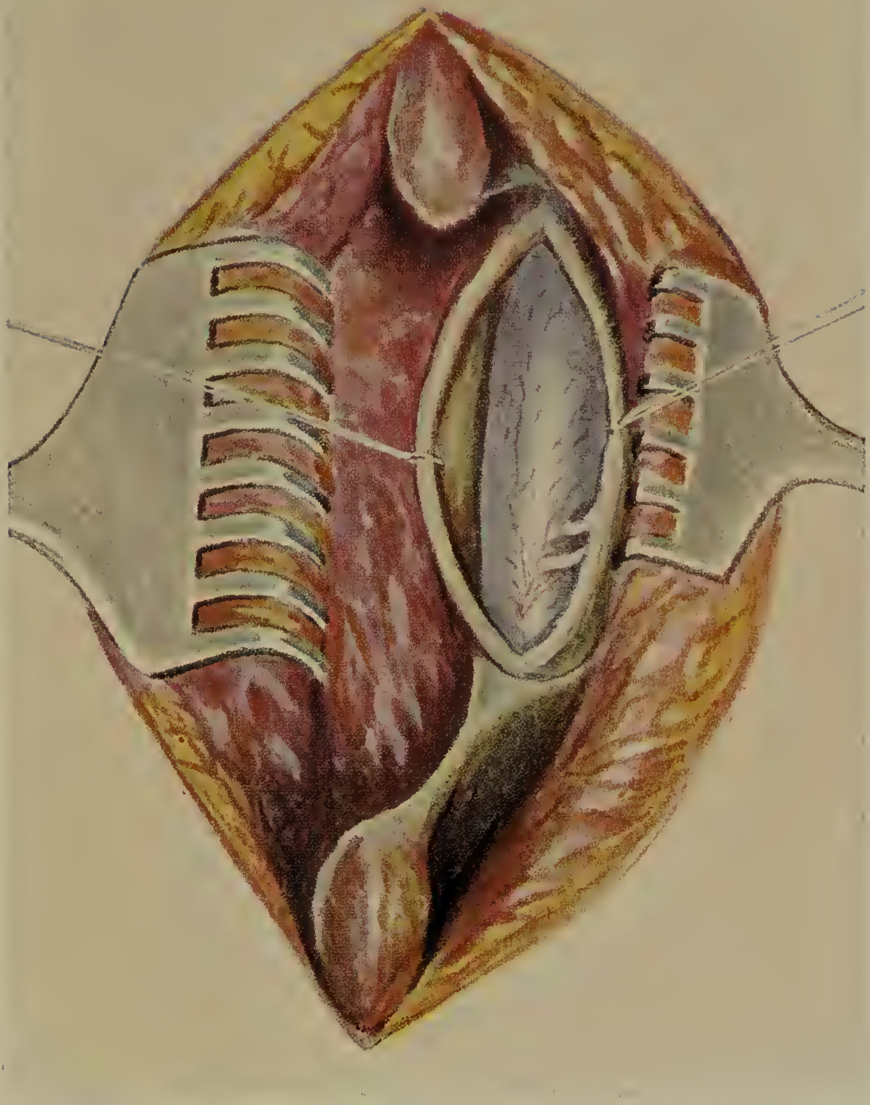

Fig. b.

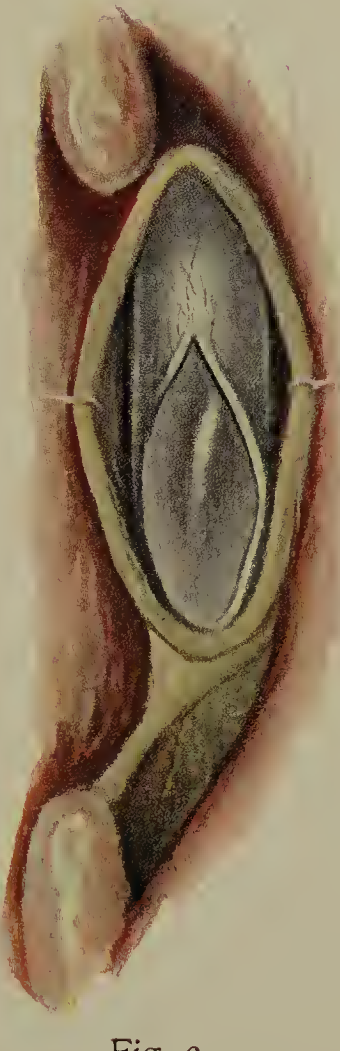

Fig. c.

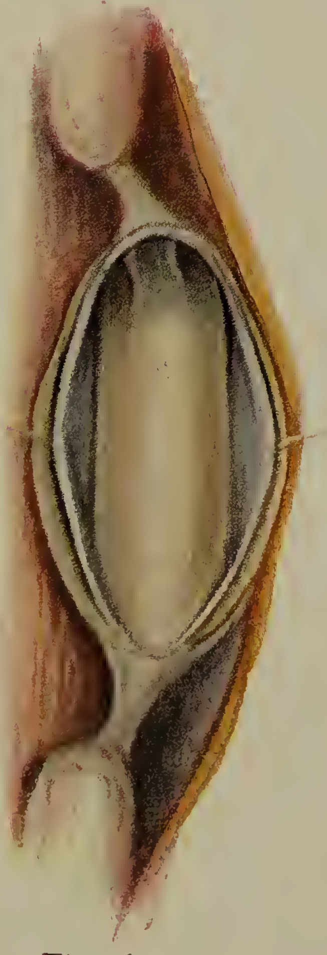

Fig. d.

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of the cord (gliosis) which he did not entirely exclude, and he also took into consideration, on account of the excruciating radicular pains, a combination with an extramedullary process. Taking everything into consideration, he thought that an opening of the dura would be indicated.

Oppenheim formulated his diagnosis as follows:

"The most prominent symptoms in this case are the severe intercostal pains, the persistence of which and their gradual development (increased severity and extent) from right to left and from one intercostal region to the other speaks for a local process which compresses the posterior nerve roots or the spinal cord itself. After excluding vertebral trouble we are bound to first think of a specific meningitis. This diagnosis, however, can hardly be sustained, in view of the repeated antisyphilitic treatments, which brought no improvement and did in no way retard the progress of the disease. Against tabes spoke the gradual progress and excessive extension of the pains as well as the unilateral spinal cord symptoms that appeared in the later course of the disease, especially homolateral exaggeration of the tendon phenomena, *Babinski* and the presence of contralateral hypæsthesia." There was also a marked rigidity in the right lower extremity with persistent ankle-clonus, an enormously exaggerated knee-phenomenon and the presence of patellar-clonus.

On the 12th of March, 1906, the patient was put under the influence of chloroform and I opened the vertebral canal to the extent of four arches. This was rendered very difficult on account of the adhesions resulting from the first operation. After splitting the old scar which measured 12 cm. in length, the normal 4th and 1st dorsal arches were removed, the cicatricially changed muscle fibres divided in the median line with extreme care. During this step of the operation three old catgut ligatures were found. The dura was covered with a layer of extremely hard indurated tissue of about 2 to 3 mm. in thickness to which cicatricial strands intimately united the dura on the right side, while on the left it was possible to detach it bluntly (Plate LII, Fig. b). With great difficulty we were successful in exposing an indurated tissue-formation from the normal upper and lower regions which in course, position, and form corresponded to the dura. Some cicatricial tissue was taken away with flat incisions until the bluish color of the dura appeared which to the naked eye did not show pulsations, but they were barely perceptible to the palpating finger.

The dura was now opened longitudinally with a scalpel. A large quantity of clear liquor cerebro-spinalis was immediately evacuated and its egress was interrupted, because the œdematous arachnoid protruded into the incision in the form of a violet-gray, shiny cyst which actively floated to and fro (see Plate LII, Fig. c).

After the dura was freely exposed and the cystic arachnoid scarified, a large quantity of liquor drained away which filled the entire depth of the large wound and which had to be sponged out two or three times. The liquor was perfectly clear and of normal appearance. After completing the longitudinal incision of the arachnoid, it collapsed, no more liquor drained away and I could examine the cord, but no tumor was found. Careful probing in an upward and downward direction and on all sides of the cord disclosed no obstacles whatever. The pulsations of the exposed cord were now distinct, especially in the upper section of the wound. However, wide cicatricial strands were found in this situation about the level of the arch of the 1st dorsal vertebra running from the inner surface of the dura to the pia and to the spinal cord (see Plate LII, Fig. d); they were carefully divided.

On the posterior roots nothing abnormal could be found in the field of operation, and looking up and down the dural sac their appearance was normal. The operation was completed by closing the dura with four interrupted linen sutures over which the musculature and skin were united. Healing per primam.

The active movements, reflexes, and the sensibility did not suffer in any way from the operation. Eleven days after the operation the *Babinski* phenomenon had disappeared on the right side. The attacks of pains did not diminish in the first two weeks after the operation but their severity became less and less, so that the patient could get along without morphin, to the use of which he had resorted up to that time. Outside of the disappearance of the *Babinski* reflex the improvement was also noticeable by the disappearance of the slight sensory disturbances found before the operation in the right and left lower extremities in the form of

Brown-Séquard's symptom-complexus. The patient had improved considerably. His appearance was brighter, but he still complained of occasional pains. When his mind was detracted he spoke lively and his movements were perfectly free. He took walks and was evidently happy. However, the disturbances did not disappear completely. He was discharged on the 29th of April, and no marked changes were noted in his condition until July, 1907.

On the 23d of May, 1910, his attending physician sent me a very favorable report. The severe attacks of intercostal neuralgia had disappeared and the occasional pains in the chest were of very short duration and did not inconvenience the patient to any extent. In the winter of 1909-10, the condition of the patient had considerably improved; he was happy and participated in all forms of pleasure which he had never expected to do before. According to the physician there is no comparison between the condition of the patient before the operation and at this time.

In this case there certainly existed a localized, circumscribed inflammatory process of the meninges which, outside of the adhesions, was proven by the enclosed collection of liquor. *Oppenheim* was of the opinion that it could not be stated with certainty "whether outside of this condition an intramedullary trouble (gliosis (?)) was active or not. From the persistence of the subjective manifestations, even though they are not as marked as before, this is not probable since the long duration of the disease and on account of the decided nosophobic character of the patient a psychogenic element must also be taken into consideration with reference to the pains."

OBSERVATION XIV, 2

Arachnitis Adhæsiva with Stagnation of Liquor. Removal of the Second to Fourth Arches of the Dorsal Vertebræ. Death from Respiratory Paralysis. See Report of Oppenheim, p. 146 ff.

The patient in this observation was a man, thirty-five years of age, who was suffering seven or eight years ago with pulmonary catarrh and hemoptysis and who, in the course of sixteen years, developed manifestations of *Brown-Séquard's* paralysis. His trouble began in May, 1904, with formications in the left leg and foot, which in the course of a few weeks extended over the entire lower extremity and the left lower region of the abdomen. There was a painful girdle sensation above the umbilicus, retention of urine, impossible ejaculatio seminis during coitus which was accompanied by pains in the left half of the penis and scrotum. In the spring of 1905 these manifestations became more severe, and the violent pains in the right sacral and lumbar regions gave rise to fainting spells. Specific medication and water cures did not relieve the patient at all; on the contrary, increasing weakness of the right lower extremity set in so that it was dragged when the patient was walking. About the end of July, 1905, the pains appeared in the right shoulder-blade and occasionally also in the right arm.

On the 1st of September, 1905, *Oppenheim* found spastic paresis in the right lower extremity, with *Babinski* and *Oppenheim* reflexes and retention of the sensation of position, while on the left lower extremity as high up as the 6th rib hypalgesia and therm-hypæsthesia were found. On the right upper portion of the back, tactile and painful sensations were somewhat reduced from the 5th to 6th ribs. Pressure on the spinous process of the 3d thoracic vertebra was very painful.

Oppenheim's diagnosis was: "Picture of extramedullary tumor at the level of the 3d thoracic vertebra; either neoplasm or obscure caries with pressure on the cord by caseous material or, perhaps, encapsulated liquor causing restriction of space. Pressure from behind and on the right side. Epidural tuberculous granulations may also play a rôle, but tumor is more probable."

Extension was at first tried, but this aggravated the condition of the patient so that he was put under the influence of chloroform on the 30th of September, 1905, and I performed laminectomy. After removing the 2d and 3d arches of the dorsal vertebræ, the dura, which lay exposed to an extent of 3½ cm., was found enormously tense and not pulsating anywhere (Plate LIII, Fig. a). In order to ascertain whether a space-restricting process springing from the walls of the vertebral canal was at play, I probed in a downward direction before opening the

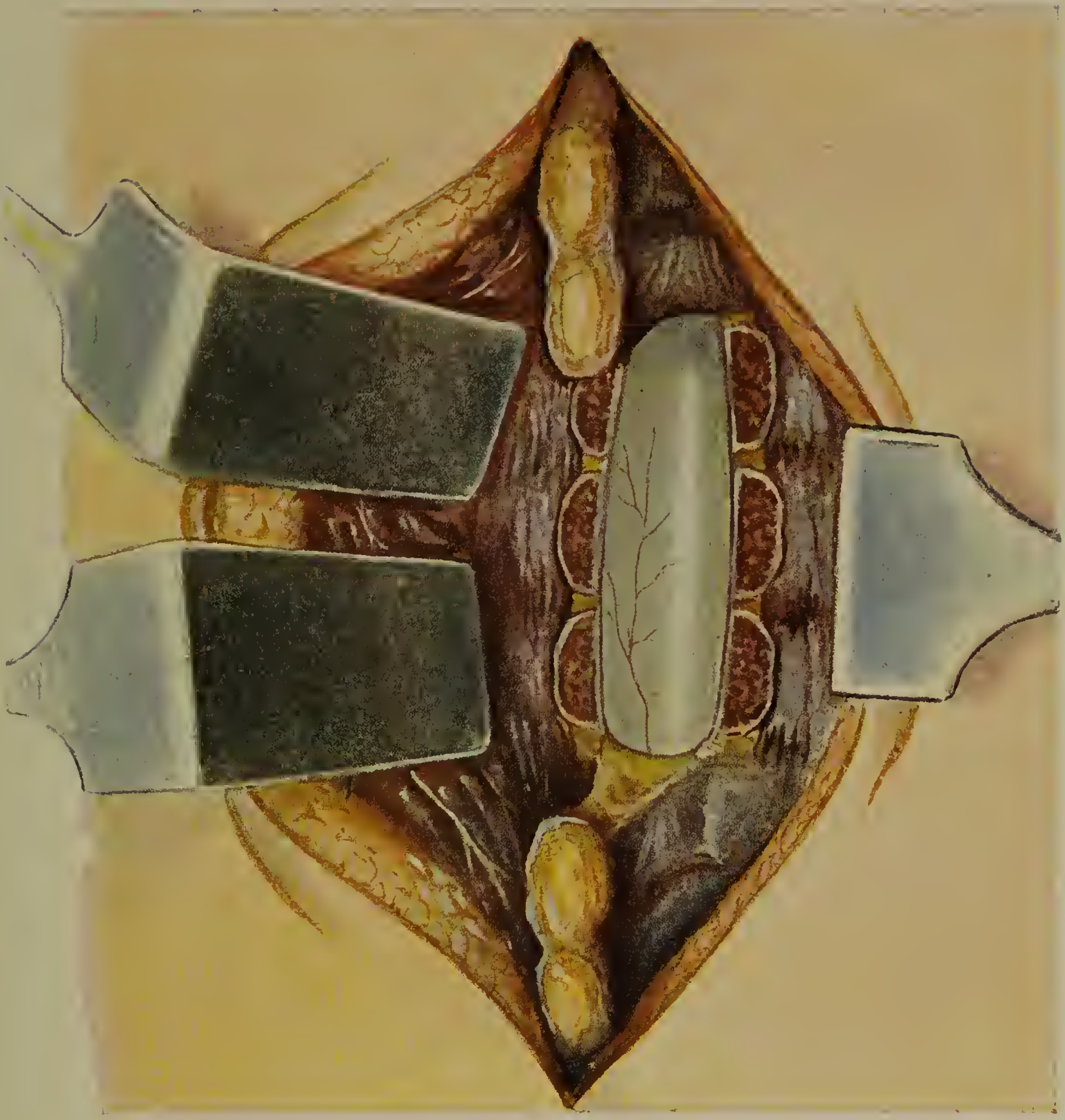

Fig. a.

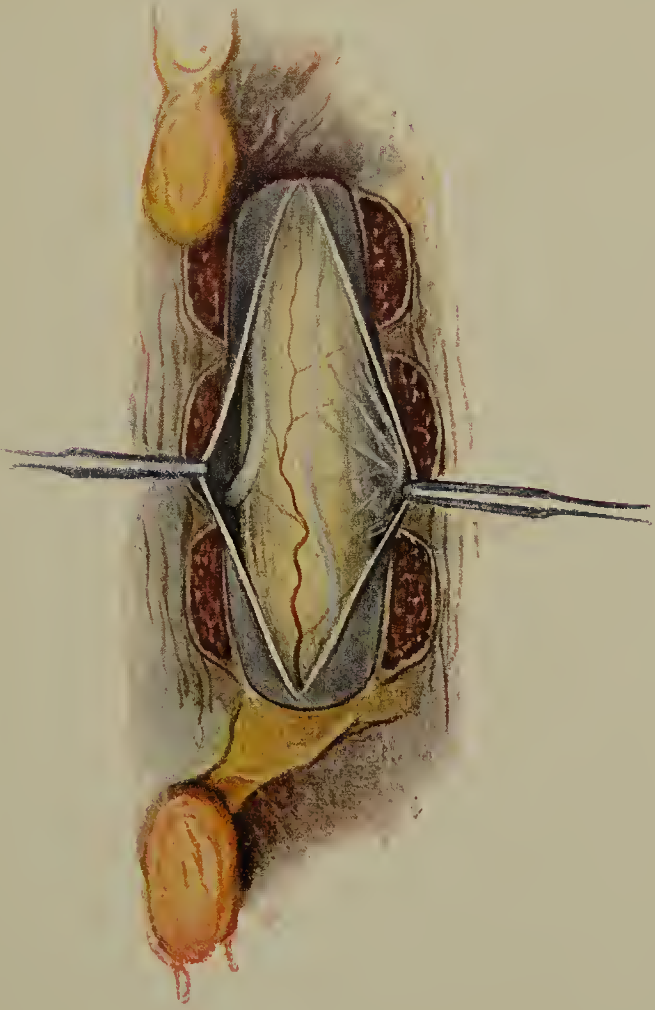

Fig. b.

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dural sac and about 2 cm. from the lower border of the cleft of the bone I met with resistance. The dura was now split longitudinally and a clear liquor burst forth in a jet in large quantities, and under considerable pressure. After this evacuation the spinal cord pulsated in a normal manner. Probing within the sac of dura showed a resistance on the right side below and about 1½ cm. laterally from the lower border of the incision. For this reason the arch of the 4th vertebra was removed and the opening of the dura continued so that the spinal cord now lay exposed to a length of 6 cm. About the level of the 3d arch to the right, broad adhesions were discovered between the two leaves of the arachnoid or better between the inner surface of the dura and the pia mater together with the spinal cord (see Plate LIII, Fig. b). They formed a sort of pocket in which the probe was caught, while the obstruction, found before the dura was opened, was evidently caused in this place by the enormous tension of the liquor. In the region of the adhesions the arachnoid was cloudy and œdematous. After they were severed, no other obstructions were met by the probe above, below, laterally or to the front. No caries of the vertebræ were discovered nor was there an extramedullary tumor, and outside of adhesions the spinal cord appeared normal.

During the operation the patient was in the semi-abdominal position and his respiration became very bad. This might have been caused by the pulmonary trouble from which he had previously suffered. An hour after the wound was closed the patient succumbed to progressive respiratory insufficiency.

I am sorry that no consent was obtained for the post-mortem examination, and for that reason an intramedullary process cannot be excluded with certainty. On the other hand, all symptoms could be accounted for by the adhesive arachnitis and the marked retention of liquor.

While in these two cases no extradural process was found, I have on other occasions observed changes between the dura and the inner surface of the vertebral canal which may have been the cause for the pathologic accumulation of liquor. I shall cite a number of observations to illustrate the various conditions found.

Extradural Processes as a Cause of Chronic Meningitis Serosa Spinalis

Inflammatory Processes

OBSERVATION XIV, 3

Tuberculosis of the Third and Fourth Lumbar Vertebræ. Operation. Cure of the Meningitis Serosa.

A woman, sixty years of age, who, outside of a hæmoptysis from which she was suffering about twenty years ago, always enjoyed good health, suffered, three months prior to her admission to the hospital, from retention of urine and had to be catheterized. This condition was repeated and became aggravated. Pains in the left lumbar and sacral regions were now added which were accompanied with weakness of both lower extremities and eight days prior to her admission a swelling was discovered in the left lumbar region close to the vertebral column. At that time she had a chill accompanied with high temperature. The patient was well nourished, pallid and had slight rises of temperature to 38° C. No abnormal conditions were discovered on the thoracic and abdominal organs.

Outside of the total paralysis of the bladder there was a paresis of both lower extremities which of late culminated in an almost total paralysis of the left extremity. Besides this the patient complained of girdle pains in the lumbar region. Below the lower lumbar vertebræ, to the left, a deep-seated fluctuation could be demonstrated. An incision to the left of the 3d and 4th lumbar vertebræ evacuated a fairly large abscess which was lined with a well-developed, tuberculous, pyogenic membrane. A fistulous tract led to the spinous and transverse processes of the 3d and 4th lumbar vertebræ, which the periosteum left exposed and which were carious. After resection of the diseased spinous processes and removal of both arches the dura was found exactly as tense and pulseless as in the first cases described, but in the vertebral canal no pus nor granulations were found. As a result of the abscess and the transmitted irritation to the dura there evidently resulted a transudation of quantities of liquor cerebro-spinalis so large that they gave rise to manifestations of compression of the spinal cord.

Under iodoform tamponade the abscess cavity healed within six weeks to such an extent that the deep wound could be closed in layers. The radiating pains disappeared immediately after the operation, and the paralysis of the bladder and the paraplegia receded very slowly. Three months after the operation the patient was able to leave her bed and attempt to walk. Five weeks later she left the hospital with tolerably useful extremities. Her bladder disturbances had finally disappeared. In the further course of the disease the functions of both lower extremities also completely recovered. She was admitted to the hospital one year later for a fistula formation, but at that time no more disturbances could be demonstrated. The patient complained of occasional weakness in the extremities. After a number of curettements the fistula closed, and for a year I could observe the patient to be in first class condition. After that time she disappeared.

We learn from this operation that in cases of caries of the vertebræ manifestations of compression of the spinal cord are not only brought about by a kyphotic displacement of the bodies of the vertebræ and not only by the filling out of the vertebral canal with granulations and pus, but secondary accumulations of liquor of circumscribed extent may also occasion or contribute to paralyses of the cord.

With reference to the last case, I must cite a passage from *Oppenheim's* "Treatise on Diseases of the Nervous System," 5th edition, p. 318. He says: "*Brown-Séquard's* symptom-complexus but rarely occurs in caries, although I have observed it in a few cases, and in one instance in which the narrowing of the vertebral canal as a result of displacement of the bone gave rise to a considerable accumulation of liquor cerebro-spinalis above the point of compression. In this instance spastic paralysis of the homolateral extremity preceded the contralateral anæsthesia for a long time."

In one case an inflammatory process in the outer layer of the dura and in the epidural tissue was the cause of the accumulation of liquor.

OBSERVATION XIV, 4

Pachymeningitis Externa. Recurrent Meningitis Serosa. After Two Laminectomies and the Removal of the Arches of Five Dorsal Vertebræ, Almost Complete Cure for a Year and a Half.

In the case of a spinster, forty-five years of age, in whom the trouble lasted for three and a half years and developed under considerable fluctuations, *H. Oppenheim* diagnosed a morbid process that was gradually compressing the lower section of the thoracic cord from the left side, which he thought was in all probability a tumor. There existed spastic pareses in the lower extremities, especially in the left, which could be lifted from the floor only two inches. There was also hyperæsthesia of the left foot and leg, therm-hypæsthesia on both sides and paralysis of the abdominal muscles on the left side. The abdominal-wall reflexes were absent on both sides, and there were also exaggerated as well as pathologic reflexes, pains in the sacrum and paræsthesias in the left region of the abdomen and groin, and disturbances of the bladder and rectum, which were accompanied with imperative tenesmus. *Oppenheim* was of the opinion that the process originated in the meninges, and that an intramedullary neoplasm was improbable. He also took into consideration a meningitis serosa circumscripta, but thought it improbable that such a condition alone should give rise to all these manifestations. The highest level of the compression corresponded to the 8th dorsal segment. He, therefore, advised to commence with laminectomy at the arch of the 7th dorsal vertebra. Pressure on this spinous process was painful.

I removed the 7th arch on the 2d of June, 1909, and the exposed dura showed only slight respiratory but no cardiac pulsations. An accumulation of liquor made it fluctuating. Extradural probing yielded no tangible points. The dura was therefore opened to a small extent and a stream of liquor was immediately evacuated. A longitudinal incision of the dura exposed the normal-looking spinal cord, which pulsated visibly. After this, the extradural probing gave a positive result in so far that, immediately below the 8th arch, it met with obstruction, which, however, when placing the probe in certain positions, passed it; probing above was free.

The 8th arch was therefore removed with the laminectome and an extradural grayish-red mass was brought to view. Since this had the appearance of granulation tissue, the opening in the dura was carefully closed with an interrupted suture and the incision covered with vioform gauze. The friable pathologic tissue extended downward to a still greater distance and its lower limit was reached only after the removal of the 9th arch. This extradural mass of tissue, which resembled a flat tumor, could not be lifted off the dura with a pair of dissecting forceps like epidural fat; it was so closely attached to it that it had to be removed with a pair of scissors. Immediate examination showed the specimen to consist of large adipose tissue-cells traversed by uncommonly numerous bloodvessels. After hardening, the report of the findings from the *Oppenheim* laboratory was as follows: "Low power magnification shows the tissue to contain few nuclei. In some places the matrix is diffusely stained, fairly homogeneous and structureless, while in other places it shows more of a fibrillary structure. High power magnification discloses small lymphoid cells contained in a closely meshed fibrillary net-work; there are also large adipose tissue cells and considerable places from which the fat has disappeared during the lixiviation of the specimen. In some places the matrix is of an œdematous character. Taking the picture as a whole, it does not impress one as being a neoplasm, but it speaks for an inflammatory process in the outer layers of the dura covered with thick strata of adipose tissue."

No changes were discovered on the bones. The tissue was split to the entire extent of the exposed field (72 mm.). Since no changes were found in the spinal cord itself and extensive probing in an upward and downward direction did not meet with any resistance, the dura was closed with three interrupted sutures and the wound closed over it in the usual manner.

On the second and the fourth day the dressings had to be changed on account of being saturated with liquor. They remained dry thereafter until the twelfth day after the operation. On the evening of that day they were saturated again, and during the change of the dressings a clear liquor was seen to trickle from the middle portion of the united incision. For three days the drainage of liquor increased considerably in quantity, and four days later it gradually disappeared without any special measures directed to that end. The patient was discharged from the hospital three weeks after the operation with her wound closed.

All clinical manifestations rapidly improved, so that twenty-six days after the operation the patient was able to stand alone and to walk through the room without any support. Five weeks after the operation hardly any manifestations were complained of and she was able to retain her urine, although she had to evacuate her bladder two or three times during the night. She was able to walk considerable distances without a cane. Four months after the operation she paid us a visit and appeared in blooming health. At that time her main complaint was a certain hyperæsthesia of the bladder, compelling her to frequently evacuate it during the day and two or three times during the night. In the reclining position or when sitting this disturbance was not complained of. She also stated that vague pains in the back of the neck and a girdle sensation in the thorax were perceived by her from time to time, while her power of motility in the lower extremities had considerably improved. She was able to walk without a cane or any other support for twenty minutes, and the exaggerated reflexes and the spontaneous twitchings in the extremities had almost completely disappeared. There existed, however, a slight hyper-sensitiveness in the left lower extremity and in the left inguinal region to contacts with the brush and pricks with the needle.

Soon, however, new disturbances, more severe than before, set in, so that the patient was readmitted to the hospital on the 8th of December, 1909 (six months after the operation). At that time she complained of weakness and rigidity in the lower extremities, more marked on the left side, and of pulling pains in the left abdominal and inguinal regions, weakness of the bladder and rectum and paræsthesias in the left lower extremity.

H. Oppenheim's examination disclosed hypertonia of both lower extremities, more marked in the left; spastic symptoms (*Babinski,* ankle-clonus, *Oppenheim*), were also more marked on the left than on the right side. The power of motility of the left lower extremity compared with the examination two months before had considerably decreased. The gait of the patient was spastic-paralytic, with marked dragging of the left lower extremity. The abdominal musculature was very flaccid and atrophic, and no abdominal reflexes could be elicited.

The temperature-sense was reduced in the left lower extremity. A zone in which the tactile sense and sense of pain were considerably reduced was found extending from the 5th to the 7th rib. A similar area was present on the outer surface of the left thigh and in the region of the left crest of the ilium, which was less marked on the right side. Under the right breast a hyper-sensitive zone to heat was present. The spinous process at the upper end of the scar of the operation was distinctly sensitive to pressure.

According to *Oppenheim,* we were dealing with a morbid process at the level of the spinous process of the 3d and 4th thoracic vertebræ, possibly an accumulation of liquor or an analogous condition found at the first operation.

Since during a period of observation of the disease extending over eight weeks, the symptoms, especially the subjective manifestations, became worse, I performed a second laminectomy on the 29th of January, 1910. Upon removal of the arches of the 4th and 5th dorsal vertebræ, the very tense dura bulged into the wound without pulsations. After splitting the dura in a longitudinal direction and the evacuation of much clear liquor the spinal cord was distinctly pulsating. It was surrounded by œdematous arachnoid which projected in the form of a cyst, synchronous with the pulsations. These conditions were undoubtedly different from those found in neoplasmata. After the arachnoid was carefully torn with dissecting forceps, without causing the slightest injury to the cord itself, no more liquor accumulated in the field of operation, but at each pulsation a jet of cerebro-spinal fluid was evacuated from above.

Intradural probing for a distance of 8 cm. above and below showed no obstacles, and since the dura was over 4 cm. widely open, no compression was present for a distance of about 20 cm. In contrast to the first operation, the dura now remained open about ½ cm. wide about the middle of the wound. After uniting the musculature and the fasciæ with interrupted catgut sutures, the skin in the wound, which was 12 cm. long, was sutured with silk.

After the operation the motility progressively improved. Of the marked spastic symptoms of the lower extremities only the *Babinski* and *Oppenheim* were found on the 12th of February, 1910. The hypertonia had completely regressed. The power in the lower extremities had improved progressively, and the right lower limb was moved normally and its coarse power was hardly reduced. While on the 1st of February the left lower extremity could not be lifted at all and on the 12th to a height of about a foot, on the 26th of February it was elevated to the same height as the right limb but with reduced power. Outside of a hypalgesic zone on the left side below the mammillary line no other disturbances of sensation could be demonstrated. The patient complained only of tensile pains in the left abdominal region and incontinence of the bladder. She was otherwise well.

Reports dated the 18th of June, 1910, and the 1st of January, 1911, showed that the improvement was steady. The patient was able to take walks for considerable distances without support, and her general condition was only slightly interfered with by the disturbances of the bladder. She visited me on the 22d of August, 1911, the picture of health. She can walk for a half hour continually without a cane and without becoming fatigued, and she was also able to ascend stairs without effort. She was on her feet almost all day and busy in the household, but her left foot still slightly dragged. The left lower extremity was somewhat sensitive to contacts. The disturbances of the bladder had considerably improved. The patient was able to retain the urine all night and when sitting. When walking she had to urinate about every hour in order to appease the tenesmus. The vertebral column was moved freely and without pain. The patient was able to busy herself the whole forenoon in the garden with a couple of heavy sprinkling cans.

In this instance we may justly assume that the inflammatory epidural granulations, the etiology of which remained obscure, caused the meningitis serosa. The recurrence may possibly be explained by the suturing of the wound of the dura after the first operation. This may possibly have occasioned an over-accumulation of liquor. Had the dura been permitted to remain open, as was done in the second operation, equalization of fluid conditions would have probably ensued.

Extradural Neoplasmata as a Cause of Chronic Meningitis Serosa Spinalis

For this etiology the following case, observed together with *Goldscheider* and *Oppenheim,* offers a good example.

OBSERVATION XIV, 5

Extradural Exostosis of the Body of the Fourth Lumbar Vertebra with Stagnation of Liquor.

A man, fifty years of age, began to suffer from attacks of paroxysmal pains radiating in the inguinal regions. Two months later his tendon phenomena of the lower extremities disappeared. In spite of the fact that the symptoms were extremely fluctuating, they pointed to a compression of the cauda equina. The excruciating pains and later on the manifestations of irritation in the region of the lumbo-sacral nerves indicated opening of the vertebral canal. After the arch of the 3d lumbar vertebra was removed the dura appeared of normal color, under strong tension and without pulsations. Aspiration evacuated a large quantity of clear cerebro-spinal fluid. Despite the relief from tension, pulsations did not become visible. The arch of the 2d lumbar vertebra was therefore also removed. After this the dura bulged into the cleft of bone in the form of a fluctuating cyst. After opening the dura mater in a longitudinal direction a large quantity of clear liquor drained away under considerable pressure, filling the wound twice, after which pulsations recurred again. Intradural probing above and below to a distance of 8 cm. and to the right and left disclosed no obstruction anywhere. Dissatisfied with these findings, I also removed the arch of the 4th lumbar vertebra; this disclosed a flat, exostosislike osseous elevation in the vertebral canal in a circumscribed area (Plate LIV, Fig. a), which evidently originated from the inner and lateral surface of the body of the 4th lumbar vertebra. A carious process or neoplasm outside of the exostosis could not be found. After further splitting of the dura (Plate LIV, Fig. b), it was found that the osseous newformation was not sufficiently developed to cause considerable compression of the cauda equina and the nerves issuing from it. It therefore became evident in this case also that the compression was due, at least in a great measure, to the tension of the fluid within the dura. The exposed cauda equina showed neither on the anterior nor on the posterior nerve roots any digression from the normal, and they were at no place of a gray color or reddened.

The stenosing section of the bone was now removed with the chisel, after which the incision of the dura and the soft parts were closed with sutures. Five days after the operation the patellar reflexes could be distinctly elicited on both sides, and the cremaster reflex and the right Achilles tendon reflex were also positive. The radiating pains had disappeared, tests for disturbances of the sense of the lower extremities were negative. Despite the entirely afebrile post-operative course of the disease, the patient died ten days after the operation from an unknown cause. No symptoms of meningeal irritation were present at any time. Since no permission was obtained to perform a postmortem examination, nothing definite could be ascertained with reference to the anatomic causes.

In the chapter on *Cauda Equina* a similar case has been spoken of. In that instance, however, the cartilaginous neoplasm springing from the body of the 3d lumbar vertebra was by far larger than in the case just described. At any rate, the main rôle with reference to compression was played in the first case also by the accumulation of liquor above the neoplasm.

Intradural Inflammatory Processes as a Cause of Chronic Meningitis Serosa Spinalis

In one particularly extraordinary case I have found inflammatory changes of a sensory root simultaneous with a circumscribed collection of liquor.

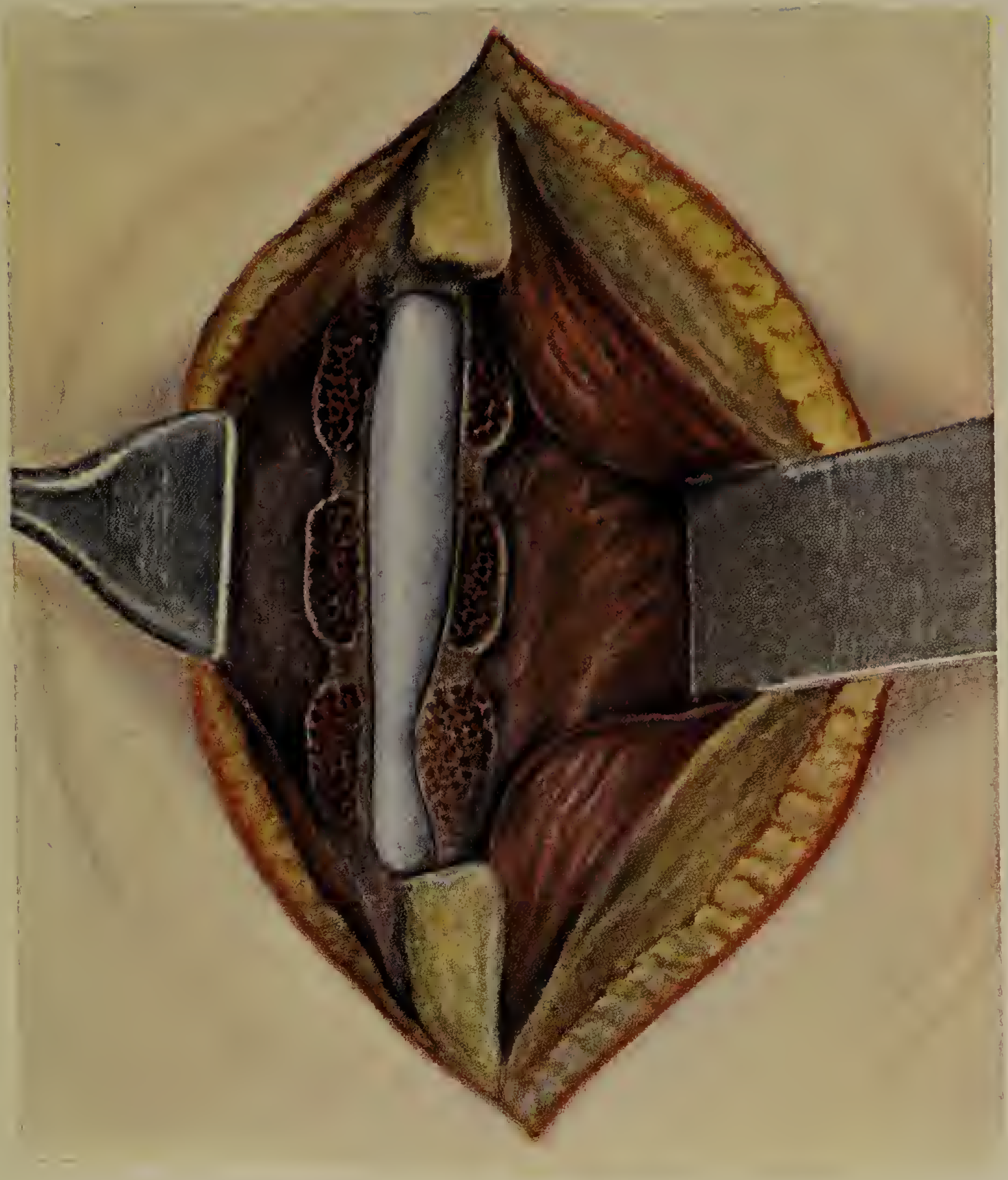


Fig. a.

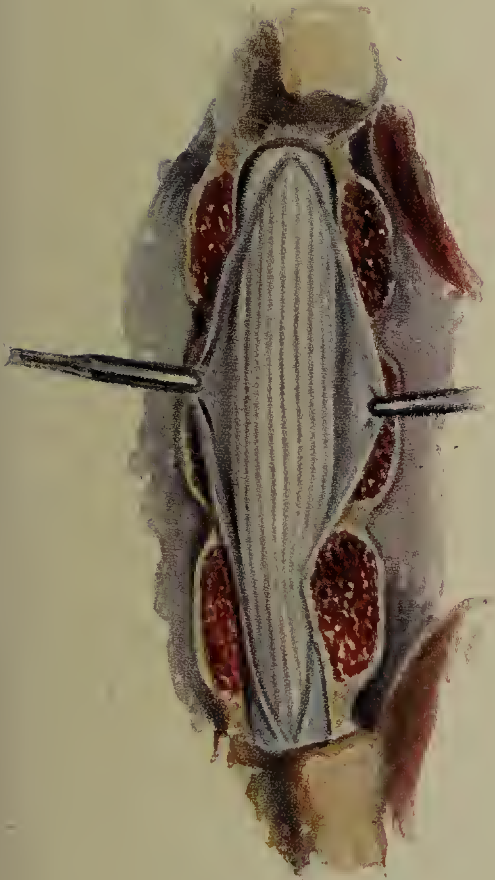


Fig. b.

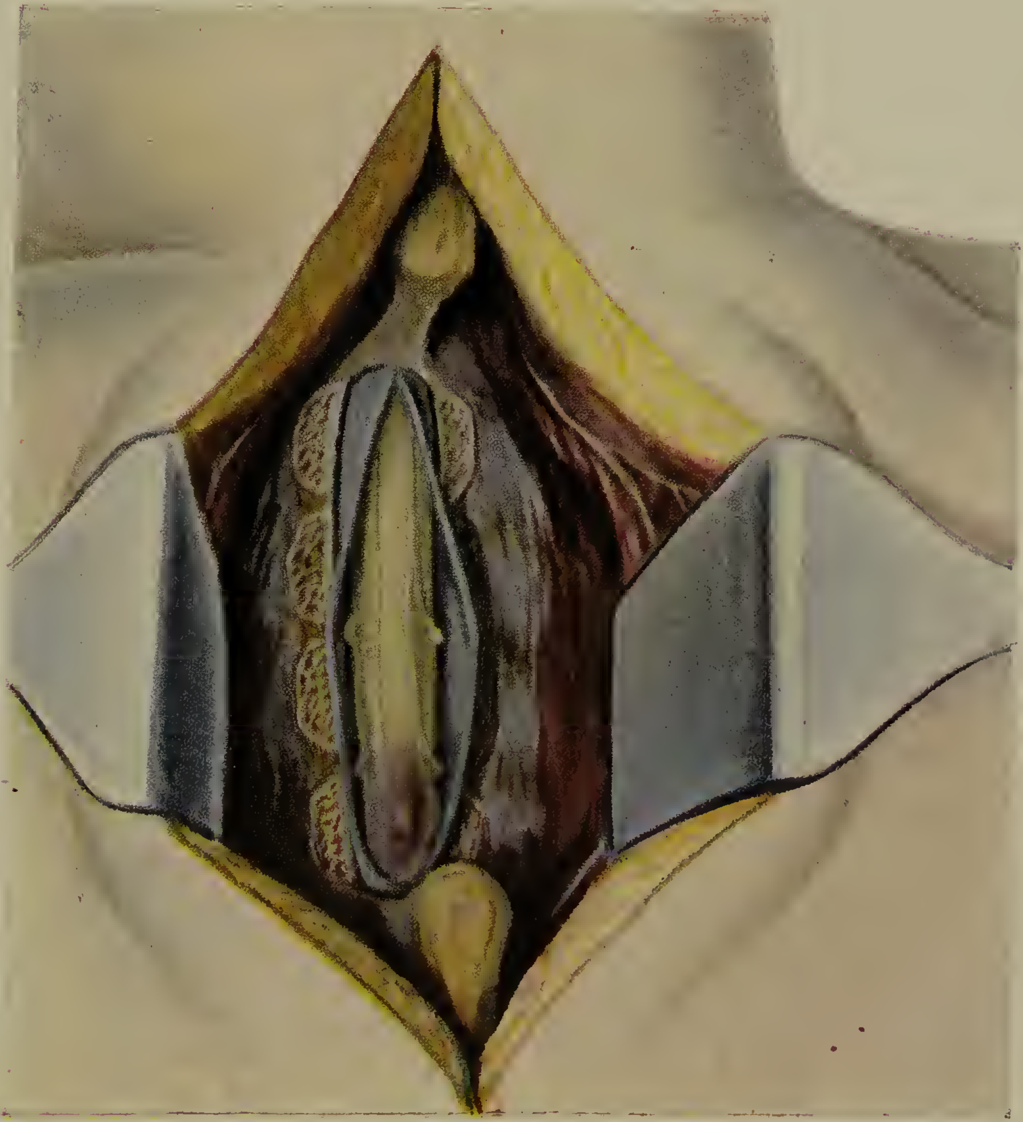


Fig. c.

OBSERVATION XIV, 6

Inflammation of a Sensory Dorsal Root with Liquor Tension. After Laminectomy and Resection of the Root Almost Complete Cure for Two Years.

The patient, thirty-two years of age, was referred to me by *Professor M. Lähr*, with the following report:

Venereal infection emphatically denied. The present trouble began in the beginning of May, 1909, with a sensation of itching along the back. While scratching himself the patient discovered (on the 20th of May) that his back was insensitive. A sense of burning gradually developed which was followed later on by pains in the right hip and on the extensor side of the right thigh; these were mainly complained of when the patient was lying. A sort of paralytic rigidity developed in the right lower extremity. He attributed the occurrence of these manifestations to a severe wetting he got a few weeks before, when he was riding a bicycle.

Findings in the beginning of June, 1909 (*M. Lähr*):

1. *Root Manifestations.*

a) Painful paræsthesias, hyperæsthesia of the skin, slight tactile hypæsthesia, decreased sensibility for pricks with the needle and differences of temperature along the spinal segments on the right side, D_{12}, L_1 and in part L_2.

b) Paræsthesias in segment D_{11} — D_9, L_2 — L_3 on the right, occasionally D_{12} and L_1 on the left side.

c) Slight weakness in the lower abdominal muscles with reduction of the faradic and galvanic irritability on the right side as compared with the left (lower dorsal segments).

d) Absence of the abdominal reflexes (D_{10} — D_{11}), weakness of the cremaster reflex, stronger on the right than on the left side (L_1 — L_2).

2. *Disturbances of Conduction.*

a) Spastic pareses of the lower extremities, more marked on the right than on the left side, exaggerated tendon phenomena (on the right side occasional clonus), *Babinski* and *Oppenheim* (occasionally on the right side), foot-reflex weak on the left side also (lateral column especially on the right).

b) In the beginning slight ataxia and disturbance in the sense of position on the right side (right posterior column).

c) Slight motor weakness of the bladder and obstinate constipation.

d) Hyperidrosis of the right lower extremity and the lower abdominal region on the right side (decrease of the galvanic resistance of conduction).

3. *No Sensitiveness to Pressure Along the Vertebral Column. No Fever.*

During the observation from the 5th to the 26th of June, 1909, no improvement was noted with the exception that the disturbances of the bladder and rectum slightly regressed. In the last few days the tension in the right lower extremity became less marked. The treatment consisted of rest, galvanization along the spine, and inunction of the back with gray ointment (altogether nine times).

The diagnosis of *M. Lähr* was as follows: Space-restricting process within the vertebral canal at the level of the segments D_9 — L_3, perhaps only D_{12} — L_1 (root involvement D_9 — D_{11}), i.e., probably postero-laterally to the right. A benign intradural tumor is suspected which causes manifestations of localized compression of a circumscribed root area.

The observation in the Augusta Hospital began on the 26th of June, 1909. *Lähr's* findings were corroborated, and in the further course of the disease striking fluctuations in the symptomatology were observed, so that some of the manifestations were not as distinct as in the beginning and others had completely disappeared. A sharply circumscribed marked hyperalgesic zone was always to be found, however, on the right side. It embraced only the anterior side of the body and extended exactly to the median line; its upper and lower limits were horizontal. This zone extended above to about the width of a hand below the umbilicus, and below it extended to the region between the upper and middle third of the thigh (D_{11} — L_1, perhaps L_2). In the middle of this hyperalgesic zone, corresponding to the middle of the inguinal canal, a hypalgesic region was found which comprised an area of about two palms of a hand

(D_{12}, L_1). The right lower abdominal-wall reflex was absent, and the cremaster reflex was less marked on the right side than on the left. At other times again, the highly hypersensitive region corresponding to D_{12} and L_1 extended to the back as far as the vertebral column.

The motor weakness of the right lower extremity was changeable and the manifestations with reference to the bladder and the reflexes, which were occasionally highly exaggerated on both sides and mainly showed pathologic conditions on the right side (*Babinski* and *Oppenheim* dorsal), were also subject to changes. The serum reaction for lues was negative.

Since the circumstances of the patient did not permit him to wait any longer, and in order to retain his position as a clergyman, he insisted upon an operation, which was performed on the 8th of July, 1909. After removing the arch of the 11th dorsal vertebra the picture typical of circumscribed meningitis serosa, due to liquor tension, presented. The non-pulsating dura mater bulged into the cleft in the form of a tensely filled cyst. Extradural probing in an upward and downward direction was performed with ease, and it met with no obstructions. The dura was opened by a small incision and a stream of clear liquor projected; enlarging of the incision evacuated a large quantity of cerebro-spinal fluid. The exposed spinal cord presented on its posterior surface numerous markedly tortuous veins. Intradural probing in an upward and downward direction was free. After the arch of the 10th vertebra was taken away, inspection was still restricted and the spinous process of the 9th had to be removed.

The spinal cord was lifted up with a couple of blunt-pointed forceps and its examination did not disclose any peculiarities. The 10th dorsal-root on the right side, however, appeared considerably thickened and very much reddened, compared with the left root, and since it corresponded to the hyperæsthetic region it was decided to resect it to a considerable extent. It was therefore seized with a pair of dissecting forceps, made tense extradurally and divided close to its point of exit from the vertebral canal. A moderate venous hemorrhage followed, which was arrested with gauze compression. The root was now made tense intradurally, so that its divided end retracted through the opening in the dura to the dural sac. It was finally seized with a pair of forceps close to the spinal cord, carefully pulled upon until the anterior root came to view and then cut through close to the cord.

It was possible to probe the anterior surface of the spinal cord by carefully lifting it up with a blunt hook. In this situation no obstruction upward and below was disclosed for a distance of at least the length of a finger from the angles of the wound. The operation was therefore completed and the dura closed with three interrupted linen sutures. The length of the wound of the dura was 70 mm. The musculature and the skin were sutured without drainage. The wound healed per primam and only a very slight trickling of liquor continued from one of the suture-tracts for fifteen days.

Immediately after the patient regained consciousness (twelve o'clock noon) the entire right lower extremity was found completely paralyzed; however, about six o'clock in the afternoon active movements of the toes of the right foot, but these alone, could be performed. Severe pains existed at the same time in the entire right lower extremity up to the inguinal flexure. After twenty-four more hours the ankle-joint could also be moved very extensively, while the knee- and hip-joints were still completely paralyzed. The sensibility in the right foot as high up as the calf was normal, but in the region of the quadriceps and at the flexure of the groin it was still reduced. Contacts with the brush over the patella were perceived as violent pains and a space about the size of a half a dollar above Poupart's ligament was still very painful to contacts. Every passive movement of the right lower extremity was still painful. The left lower extremity was normal with the exception of spontaneous pains, which were even more intense in this limb than in the right.

The patellar- and Achilles tendon reflexes were absent on both sides. The cremaster reflex and the right lower abdominal reflex were also wanting. *Babinski* and *Oppenheim* were positive.

On the following day a number of blebs of considerable size developed on the right gluteal region, which healed within fourteen days. Ischuria paradoxa followed the operation and a few days later the patient was able to void his urine after persistent effort. Eight days after the operation the patellar- and heel-reflexes could be elicited again, the right quadriceps began to functionate and the hyper-sensitiveness of the right knee became less. After five more days all movements of the lower extremities, with the exception of flexion, extension, and adduction at the hip-joint, could be executed again. The tendon-periosteal reflexes of the left lower extremity were highly exaggerated for a considerable period.

At his discharge from the hospital (17th of August, 1909) no girdle sensation and no paræsthesias observed in the beginning of the disease were complained of, and the patient stated he had a certain sense of tension in the back and that the weight of the bedclothing on the right lower extremity was unpleasant. He could evacuate his bladder without effort. The joints of the right lower extremity, the mobility of which had still more improved, persisted in a certain tension, and certain spastic manifestations could still be demonstrated (*Babinski, Oppenheim,* foot- and patellar-clonus). The right cremaster reflex was absent and the lower abdominal-wall reflex could not be elicited on either side. Slight sensory disturbances for point and blunt and for thermic qualities could be demonstrated in the right lower extremity. The tendon reflexes of the left lower extremity were exaggerated.

An examination made three months later (November 15, 1909) showed that the patient had improved to a greater degree. Pareses still existed in the right lower extremity, which, however, were so slight that the patient was able to walk short distances without effort. Spastic manifestations could still be demonstrated in the right lower extremity. With the exception of a narrow zone in the flexure of the right groin, in which, point and blunt were interchanged, the sensibility was everywhere intact. The patient was in perfect health and complained only of slight paræsthesias in the right thigh and hyperæsthesias for contacts in the right knee-joint, in the right flexure of the groin, in the hypæsthetic zone mentioned above and on the outer side of the left thigh. Later on, his health was restored to such a degree that from the 1st of April, 1910, he was actively engaged in the exercise of his duties as a clergyman. At that time he was able to walk a distance of eight miles without interruption. His sexual functions were restored.

An examination of his nervous system ten months after the operation (7th of May, 1910) showed no marked differences. However, his right lower extremity had improved to such an extent that the patient was able to walk for an hour without fatigue and to perform his duties without inconvenience. The spastic manifestations, however, while very slight, could still be demonstrated. A letter dated the end of July, 1911, informs us that the condition of the patient was still better.

Since in my other cases of meningitis serosa I have never found any changes in the roots, we are justified in concluding that the inflammation of the 10th sensory root in this case was the cause of the accumulation of the liquor. The alternately increasing and regressing tension of liquor causes characteristic morbid manifestations.

Accumulation of Liquor in Intradural Neoplasmata

In almost all cases of intradural neoplasm I have invariably observed a greater or less accumulation of liquor cerebro-spinalis above the tumor. As far as the operation for tumors is concerned, this occurrence is important for the reason that a tense cyst is in a certain sense also a tumor, as for instance in hydrocele, also for the reason that its presence in the spinal cord may cause all the manifestations produced by a solid tumor.

A fact of still greater importance is that the existing collection of liquor may occasionally mask the presence of an intramedullary neoplasm, and that after the operation, during which perhaps no pathologic changes were discovered on the cord, a great part of the manifestations may disappear for a considerable period. The following case from the practice of *Professor Oppenheim* and *Dr. Placzek* illustrates such a condition.

OBSERVATION XIV, 7

Intramedullary Neoplasm (?).

A woman, fifty-three years of age, observed in 1903 an increasing weakness mainly in the right arm and to a lesser extent in the right lower extremity; piano-playing with the right hand was impossible. Pains occurred simultaneously, which began in the upper section of the thoracic portion of the vertebral column and radiated to the right shoulder. In the beginning of November, 1905, the 1st to 4th interosseous spaces and the ball of the little finger of the right hand were distinctly atrophic, and the inward movement of the right thumb powerless. The sensibility was everywhere intact. The skin in the lower region of the neck down to the 2d rib was considerably reddened and hypersensitive.

The right lower extremity was markedly paretic; *Babinski* positive. The vertebra prominens was sensitive to the touch. A space-restricting process in the vertebral canal at the level of the 8th cervical and the 1st dorsal segments was suspected.

Laminectomy was performed on the 15th of November, 1905, and the removal of the arches of the 7th and then the 6th and 5th cervical vertebræ disclosed considerable tension of the dura without pulsations. Puncturing the dura ejected a high stream of liquor, and the free exposure of the spinal cord showed it pulsating and perfectly normal in appearance. After removing the arch of the 1st dorsal vertebra and correspondingly prolonging the incision in the dura, the arachnoid showed jellylike changes and a violet-red color; it bulged into the wound in the form of a cyst (compare Plate LIV, Fig. c), but no solid tumor was found.

Careful probing in an upward and downward direction met with no obstacles, and the abdominal position of the patient, with deep-hanging head to the front, permitted thorough inspection of the canal of the dura in all directions, during which nothing of a pathologic nature was visible.

According to these findings we were dealing with a meningitis serosa ex arachnitide chronica with compression of especially the 8th cervical segment. The incision of the dura, measuring 75 mm., was closed by two linen sutures, and the wound united in the usual manner.

Two days after the operation considerable improvement in the movements of the right lower extremity was observed, which rapidly became more marked. while in the hand and fingers no progress was demonstrable.

In January, 1906, the patient was able to stand and walk for a short distance when supported. While the improvement was very slow it, nevertheless, progressed. In the beginning of 1907 she could walk through the room when led by both arms. Her general condition was excellent and the power of her right lower extremity was about the same as that of the left. She complained of no pains whatever. Both arms were freely movable and of equal power in the shoulder-, elbow- and wrist-joints.

The atrophy of the interosseous spaces and the ball of the little finger of the right hand remained in the same condition as before, but did not get worse. Oculo-pupillary symptoms did not exist.

Soon thereafter, however, disturbances of the mobility of the arms and lower extremities gradually developed again, which pointed to a new compression in the middle and lower portions of the cervical enlargement of the right side. In June, 1907, *H. Oppenheim* examined the patient, and the progressive symptoms, together with the findings at that examination, caused him to conclude that there existed a slow-growing intramedullary neoplasm. The patient died at her home in April, 1908, and I regret that no autopsy could be performed.

While in this instance anatomic proof is lacking, the clinical findings permit the assumption of the gradual development of a slowly growing intramedullary neoplasm with a certain degree of probability, which was evidently accompanied in the beginning of the trouble with a circumscribed serous meningitis that gave rise to an accentuation of the symptoms which dominated the clinical picture. After removing the liquor tension by the operation a striking improvement set in, that continued for a year, after which the manifestations gradually recurred and caused the death of the patient. However, in spite of this experience, an assumption of intramedullary neoplasm in every case of chronic meningitis serosa is not justifiable.

Diagnosis of Meningitis Spinalis Chronica

While numerous observations with reference to the clinical picture of this condition have been made in the last years, a great many points need elucidation. Up to this time we are hardly in a position to make a diagnosis between it and solid neoplasmata. *Horsley* gives, in the work mentioned before, a few differential points. He says that in circumscribed serous meningitis the initial pains extend over greater areas, while those of neoplasmata of the spinal cord are in most instances limited to a region of a certain nerve root. For instance, hyperæsthesia of an entire extremity is never observed in cases of tumor, in which instance there is either a distinct hyperæsthetic zone at the upper limit of the anæsthetic region or such a zone which corresponds to the nerves or to the nerve roots affected by the tumor. If the hyperæsthesia embraces large territories, an entire series of nerve roots or their segments must be in a state of irritation. The extent and distribution of the hyperæsthesia can, therefore, be made use of in the differential diagnosis. Furthermore, tactile anæsthesia is not complete, although it extends over large regions, while the paraplegia may be developed to a considerable degree.

However, all these points are not characteristic. In our cases at any rate, no differential diagnosis was successful, because the clinical manifestations do not differ from those of neoplasm. It is especially noteworthy that in cases of meningitis serosa in which the accumulation of liquor, although limited to a certain level (therefore exercising its deleterious influences on an entire cross-section of the cord), will principally point to an exclusive compression of one-half of the cord by the existing symptoms of *Brown-Séquard's* unilateral lesion.

According to our experiences one fact may be utilized for arriving at a probable diagnosis of serous meningitis, and that is the striking fluctuations in the symptoms. For instance, the skin and tendon phenomena may now be absent and soon return. The pains are subject to considerable changes. The power in the lower extremities is at times so good that the patient is able to walk, and at other times again the pareses may render him entirely helpless. The sensibility frequently presents great fluctuations, especially in the various sensory qualities found at different times. For an example, the striking change in the senses of temperature and pain may be accompanied with a constant reduction of the sense for contacts with the brush. However, all these facts are not of sufficient consequence, because they are also observed in instances of solid neoplasmata.

Meningeal symptoms of irritation are more characteristic when observed in places distant from the morbid process proper and when preceding its development for a long time, viz.: violent occipital pain or pains in the back of the neck in suspected neoplasm of the dorsal portion. These pains, which were very annoying for a period of three years in one of our patients (compare Observation XV, 1, p. 1104), show a meningeal irritation of great extent, occasioned by a chronic inflammatory process, as a rule not observed in instances of tumor. A point of differential value from such symptoms of irritation in neoplasmata of the cervical portion of the cord may be found in the pains in the lateral regions of the neck which must be looked upon as root symptoms (compare Observation XIII, 2, p. 1011). In neoplasmata of the deeper sections of the spinal cord the diagnosis is not so difficult.

It has been pointed out in our discussion that liquor tension above intradural tumors may lead to an erroneous diagnosis with reference to the level of the morbid focus. Accumulations of liquor in abnormal quantities and under high tension within the sac of dura also occur in chronic inflammatory processes or induration of the spinal membranes and may, in an analogous manner, cause suspicion of compression at a higher level.

Now the question presents itself, may lumbar puncture help us in making a correct diagnosis? I must answer: No. The following example may bear me out.

OBSERVATION XIV, 8

Trauma as a Cause.

A man fell with his bicycle and sustained a contusion of the cervical portion of the vertebral column. He was under observation for a number of months and developed all manifestations of compression of the cord. A number of lumbar punctures were made by the physicians who were observing him and by myself at the time he was admitted to our hospital. The punctures showed no abnormal pressure. Continuation of the very severe symptoms caused me to remove the arches of the 2d, 3d and 4th cervical vertebræ, during which an abnormal tension of liquor was discovered when the fluid was evacuated upon incising the dura. After this, pulsations set in and the liquor drained only from the cerebral end of the incision of the dura and not from its caudal section. The pia appeared unchanged. After this procedure the patient was cured and the manifestations of paralysis disappeared. I saw him two years later. He was then free from disturbances, and disappeared from under my observation.

It may be argued here that, perhaps, puncture at the level of the supposed seat of the trouble could have cleared the diagnosis. In non-suppurative processes we may puncture, of course, and under such circumstances the accumulation of liquor may be discovered. As I have pointed out above, in almost all neoplasmata of the spinal cord I have operated upon, such accumulations of liquor tension were found above the neoplasm and in a few cases I have also found it to exist to quite a decided degree below the tumor. The projection of the liquor in a stream is not a diagnostic criterion whether a tumor exists or not.

The **etiology** of these cases has thus far been ascribed to syphilis, tuberculous granulations and injuries, and, according to *Horsley,* also to gonorrhœa. By making cross-sections of the spinal cord, this author has furthermore demonstrated in one instance the existence of sclerotic changes which began below and extended in an upward direction. The ascending degeneration had affected one side more than the other. In this particular instance the condition was quite an advanced one. In another case of *Horsley,* after the wound healed, the patient died of syphilitic myocarditis and the cord was found flattened and showed a circumscribed peripheral sclero-gliosis, which affected sympathetically all columns to the cervical portion of the cord.

The spinal cord subjected to excessive pressure from liquor must, in the first place, suffer changes of an ischæmic nature. It later shows œdematous infiltration, and its conductivity is thereby severely damaged.

With reference to **treatment,** I must say that since, according to my experiences, spontaneous regression does not take place, laminectomy is the method of choice. In non-suppurative processes the dura mater should be opened. This is much the more indicated since, up to the present time, we possess no other remedy which will aid us in the differentiation of meningitis serosa spinalis ex arachnitide chronica (or call the affection whatever you may like) from tumors of the spinal cord.

Contrary to the practice in extirpations of neoplasmata, the incision into the dura should in these cases not be sutured, but the musculature and overlying fasciæ should be united with buried catgut sutures. The excessive discharge of liquor may, if the case be so treated, find its way from the sac of dura into the large wound cavity and there be absorbed.

Horsley believes that many cases of so-called acute myelitis are in all probability of real meningeal origin. Laminectomy and free drainage of the subdural space may, therefore, halt the entire process in these instances and obviate the serious consequences following it. This question is of great importance because, if we reflect for a moment over what has been said above, it will at once become apparent that a new field is opened here for surgical intervention in a class of cases which thus far have been extremely difficult to manage. An example follows.

OBSERVATION XIV, 9

Meningomyelitis of the Thoracic Cord with Spindle-Shaped Swelling. Slight Improvement after Laminectomy.

A man, thirty-nine years of age, who was of powerful build and had always enjoyed good health, became ill in the middle of January, 1909, with very severe neuralgic pains in the lower section of the trunk, which at first affected the right hip and later on, both. This was accompanied with slight abnormal sensations in the feet. The pains ceased in the middle of February, but a weakness was observed in the left lower extremity which was mainly manifest when the patient was getting on or off his bicycle. At the end of July he could not use his left foot in mounting a horse, and therefore could not participate in the parade of the war festival. Bladder and rectum were normal. On the 2d of August the old pains recurred, this time more marked on the right side, and they became localized in both knees. When walking the patient stumbled (mainly with his right lower extremity), but he was able to reach the bed when supported by the physician. On the evening of the 2d of August catheterization became necessary for the first time.

On the following day the sense of position of both feet had disappeared and a day later (4th of August) diminished sensation was demonstrated on the outer side of the right lower extremity and hyperæsthesia on its inner surface. On the evening of the 4th of August the same conditions were found in the left lower extremity. On the 5th the patient complained of very violent radiating pains in both hips and feet, especially when changing his position. On the 6th the right lower extremity was completely paralyzed, but sensation was retained to a slight degree. On the left lower extremity only the toes were actively movable. In the evening, only the first three of these showed slight active mobility and the entire left extremity was, like the right, completely paralyzed. Pricks with the needle were perceived as a sense of pressure on the inner surfaces of both lower extremities, while, generally speaking, there was anæsthesia.

Since the 2d of August the bladder, and since the 4th the sphincter ani were completely paralyzed. On the 7th, girdle pains were complained of at the level of the umbilicus, and on the afternoon of that day very violent attacks of pain in the back and sacrum. On the 10th, superficial decubitus was found on the gluteals. For a long time the patient was addicted to large doses of morphin. An inunction cure (3.0 daily) was instituted in the beginning of August.

I examined the patient at his home on the 15th of August. A complete flaccid paraplegia of both lower extremities, paralysis of the abdominal muscles and of the sphincter vesicæ et ani were found. There was also a total anæsthesia, which extended to the median line in front between the umbilicus and symphysis pubis, and posteriorly to the spinous process of the 2d lumbar vertebra. The reflexes were entirely extinguished, with the exception that in the left foot the *Bechterew-Mendel* reflex could be elicited, and on the 12th of August a very slight response was found by tapping the left knee.

As I shall explain more fully in the epicrisis, I suspected an interrupted conduction in the spinal cord at the level of the arch of the 9th dorsal vertebra which may be due to an inflammatory condition. After a consultation with *Oppenheim* on the 20th of August he expressed his views as follows:

"The paraplegia was preceded for a long time by pains and paretic manifestations. This does not correspond to the picture of primary disease of the spinal cord but to a morbid process springing from the meninges or the vertebræ; most likely specific. The excruciating pains at the onset of the disease speak for vertebral trouble (caries or tumor), yet no deformity whatever is to be found nor is there any sensitiveness to pressure. Furthermore, it is very uncommon for caries or tumor of the vertebral column to develop in such an acute and severe form. Even in tumors springing from the meninges rapid development of paralytic manifestations and the symptomatology, pointing to a total interruption of conduction, is an unusually rare occurrence.

"The nature of the trouble is, therefore, indistinct and problematical. The severity of the disease and its resistance to antisyphilitic treatment indicate exploratory laminectomy, especially for the reason that the affection apparently springs from the surroundings and not from the cord itself.

"At what level should the laminectomy be performed? D_{12} falls into the region of total anæsthesia; D_{11} is surely participating and probably also D_{10}; this explains the absence of the lower abdominal reflex. Removal of the arches of the 9th (maybe the 8th) and 10th dorsal vertebræ should therefore be carried out. Our recent experiences suggest that it would, perhaps, be best to commence with D_9 in this instance."

The operation was performed on the 21st of September, 1909, in the presence of *H. Oppenheim.* The anæsthetic used was chloroform. The arch of the 9th dorsal vertebra was removed first and the spinous process of the 8th was also taken away, because it prevented inspection on account of its oblique course. Absolutely no pulsations were noticeable on the dura, and extradural probing met with no obstacles in any direction. The arch of the 10th vertebra was removed next and the dura split lengthwise. A great quantity of liquor was evacuated. Considerable venous hemorrhage ensued when the borders of the incision of the dura were retracted; this was due to the tearing of isolated adhesions of the arachnoid. The cord disclosed a spindle-shaped swelling, which was equal on both sides and which completely filled the entire cleft of the bone. The slightest contact of the cord with sponges at once caused considerable hemorrhage from the dilated arachnoid veins. A small median strip of the spinal cord showed a normal yellowish appearance, while its lateral portions were of a grayish-blue hue and presented on the surface a jellylike appearance. A circumscribed neoplasm did not exist. Even after the existing arachnoid-adhesions were in part removed, **the cord did not pulsate.** Careful probing upward, downward, posteriorly, laterally, and also to the anterior surface of the cord disclosed no obstruction.

In order to keep up the decompression and enhance the drainage of the accumulated liquor, the dura was not sutured. The musculature was united with two buried catgut sutures and the skin closed over it by an exact suture of the skin. No drainage.

Three days after the operation the patellar reflex could be distinctly elicited on the right side, and on the left it was only slightly present; the same was true with reference to the *Oppenheim* reflex. Stroking of the skin of the thigh on the right side elicited a weak contraction of the quadriceps, and on the left outward rotation. The skin- and periosteal-reflexes soon became stronger, so that on the 9th of September they were very lively on both lower extremities and considerably exaggerated as compared with the normal. The patient left for his home on the 25th of September, on which day the reflex irritability of the lower extremities became so marked that simple stroking on any part of the skin caused not only elicitation of reflexes but movements and, occasionally, also contractions of the musculature of the thigh. The patellar reflexes were very exaggerated. Of pathologic responses only the *Oppenheim* phenomenon was present to a marked degree.

On the day of the discharge of the patient from under our care the sensibility had improved. Contacts with the brush were perceived in the inguinal regions indistinctly, and at a distance of about two or three fingers higher they were felt well. While for contacts with the point of the needle and the brush the lower extremities were totally anæsthetic, the inguinal regions perceived contacts with the point as a blow, and three fingers higher as point. The differentiation between heat and cold was uncertain in the inguinal regions, but a little higher it was perceived distinctly. Cold, however, was felt correctly on both sides in the upper region of the thigh about 2 or 3 cm below *Poupart's* ligament.

The motility was changed only inasmuch that the contractions of the abdominal muscles to pressure and coughing occurred with lessened power.

From the evening of the 30th of August on (nine days after the operation), clear liquor trickled from a suture-tract, so that the saturated dressing had to be changed every two or three days. This draining tract was also closed on the 12th of September. From the 17th of September on, the urine, which up to that time had to be taken away with a catheter, was spontaneously evacuated. Defecation was occasionally also spontaneous.

For a few weeks prior to the operation the temperature showed evening rises to 38.6° C., and on one occasion 38.8° C., while the morning temperature was normal or only slightly elevated. This condition persisted for twenty-seven days after the operation, and from the 18th of September on, the temperature was perfectly normal.

Information from the attending physician (23d of October, 1909) speaks of an entirely satisfactory general condition of the patient; he had discontinued the use of morphin. The pain was only perceived during strong reflex contractions, when he kept both of his lower extremities firmly pressed together. Catheterization was only necessary when the temperature rose (38° C.) as a result of fermentation in the bladder, which required lavage. The bowel action responded to enemata and the function of the sphincters was normal. The tactile sense for pin-point and pressure had gradually descended to about the width of a hand below the inguinal flexure on the thigh and to a somewhat greater extent anteriorly than behind, while heat and cold were perceived still lower down to about the middle of the anterior surface of the thigh. The electric current was perceived to about the same extent. During its use the musculature of the left lower extremity reacted more promptly than that of the right. The patient rested no longer on the water cushion and no indications of decubitus were noted. He was able to sit up alone, and was rolled about in a wheel-chair in the garden. Under the influence of the iodides sensation returned in the entire right lower extremity and on the inner surface of the left lower limb to about the middle of the thigh (end of 1909). He now felt the introduction of a rectal tube.

A report from his physician, dated August 22, 1911, speaks of a tolerable condition. With the exception of a slight active mobility of the toes, a spastic paraplegia was present. The intolerable pains in the back and sacrum had improved to such an extent that the patient expressed satisfaction and was able to be out without inconvenience. Bladder and rectum continued as before.

Following the attacks of severe pains, which recurred after a longer interval and after a slight paresis of the left foot that persisted for a number of months, excruciating pains developed within a few days (acute onset) again; this was followed by a complete paralysis of the lower half of the body—a circumstance that conclusively spoke against tumor originating from the meninges. Considerable rises of evening temperature were present, however. On the evening of the 1st of August, for instance, it was 38.6° C. (taken by axilla), and catheterization was resorted to for the first time on the evening of the 2d of August. Since the vertebral column appeared perfectly normal, I thought of an inflammatory process about the meninges. The exudation into the sac of the dura, or, perhaps involvement of the spinal cord itself gave rise to a paraplegia. Nothing spoke for syphilis, and a course of inunctions was useless. The diagnosis was, therefore, doubtful. *Oppenheim* also entertained this view. The rapid progress of the disease indicated immediate laminectomy.

The operation disclosed the inflammatory nature of the trouble. The adhesions of the arachnoid, the marked turgidity of the vessels, causing hemorrhage at every contact, and the abnormal accumulation of liquor spoke for a participation of the soft membranes. The cord itself was also inflamed, as shown by its peculiar spindle-shaped, swollen appearance, increased thickness, the lack of pulsation consequent thereto and its change in color. The decompression following the opening of the dura had a beneficial influence. The excruciating pains vanished and the constant use of morphin was abandoned by the patient. The paralysis of the sphincters disappeared and the anæsthetic regions decreased in extent. The extraordinary exaggeration of the reflexes of the lower extremities was not to be looked upon, as this observation teaches, as a favorable symptom for the return of active mobility.

Meningitis Serosa Acuta Circumscripta

Observation XIV, 9, has brought us to a discussion of this form of the disease because, despite the development of the trouble, that lasted a number of months, the manifestations in that particular instance were of such character that they must necessarily be looked upon rather as an acute than a chronic disease. However, its etiology remained entirely unknown. Besides the chronic form of paralysis of the spinal cord, of which we were speaking up to this time, we have to contend with an acute or subacute phase of the disease which is occasioned by suppurative-necrotic osseous processes in the vertebral canal. The analogy of the latter form is found in the so-called meningitis serosa cerebralis spoken of by otologists.

Since I have observed a similar disease on the vertebral column and spinal cord, a thorough description of the following observation seems to me indispensable.

OBSERVATION XIV, 10

Suppurative, Necrotic Processes of the Arch of the Fifth Cervical Vertebra, with Secondary Meningitis Serosa Acuta. Cure Following Laminectomy of the Third to Sixth Arches.

A merchant, thirty-two years of age, was the victim of an assault on the 5th of June, 1905. We shall not speak of the numerous injuries he sustained at that time, because they have been described in the chapter on "*Cerebral Abscesses*" (Observation X, 3, p. 852). It is sufficient for us to note at the present time that a bullet from a revolver had injured the cervical portion of the vertebral column and the spinal cord at the level of the 5th and 6th spinous processes on the right side. *Brown-*

Séquard's paralysis resulted, which, however, was not complete, and we concluded that the cord was injured about the level of the 6th cervical segment.

The patient arrived in Berlin on the 10th of September, 1905, and was under the treatment of *H. Oppenheim* and myself. At that time his general condition was satisfactory and he was able to walk about supported by a cane. The muscles of the entire right arm, including those of the shoulder-blade, were atrophic, and the triceps and the extensors of the forearm were mainly affected. This, of course, caused diminished faradic irritability on the right side as compared with the left. Similarly, but to a lesser degree, the musculature of the right lower extremity was atrophic as compared with that of the other side. There was a slight contracture of the right biceps. The reflexes were exaggerated on the right arm and on the right lower extremity. The examination of the sensation showed normal conditions on the right half of the body, with the exception of the musculature of the calf, which was hypersensitive to pressure. From the sternal angle and in both extremities of the left side the trunk showed a slight diminution of the sense of pain and a distinct decrease of therm-æsthesia, while tactile sense was normal.

In spite of the satisfactory general condition of the patient, slight rises of temperature would occur now and then, and the frequency of his pulse was at times markedly increased, indicating the development of a focal disease.

Occasionally the manifestations pointed to an irritation of the cervical cord. For instance, on the 15th of October individual twitchings of the right arm and lower extremity were observed, which were repeated in the following days and then disappeared. During that time the patient was suffering much from erections and pollutions. To these, excruciating pains were added, which began in the shoulders and radiated to the back of the neck and both upper extremities. Up to that time the patient was able to walk about the room when supported by the sister, but later he was unable to leave his bed on account of extreme loss of power in the right lower limb, which, after a few steps, was unable to support the weight of the body.

While these threatening symptoms were fluctuating up and

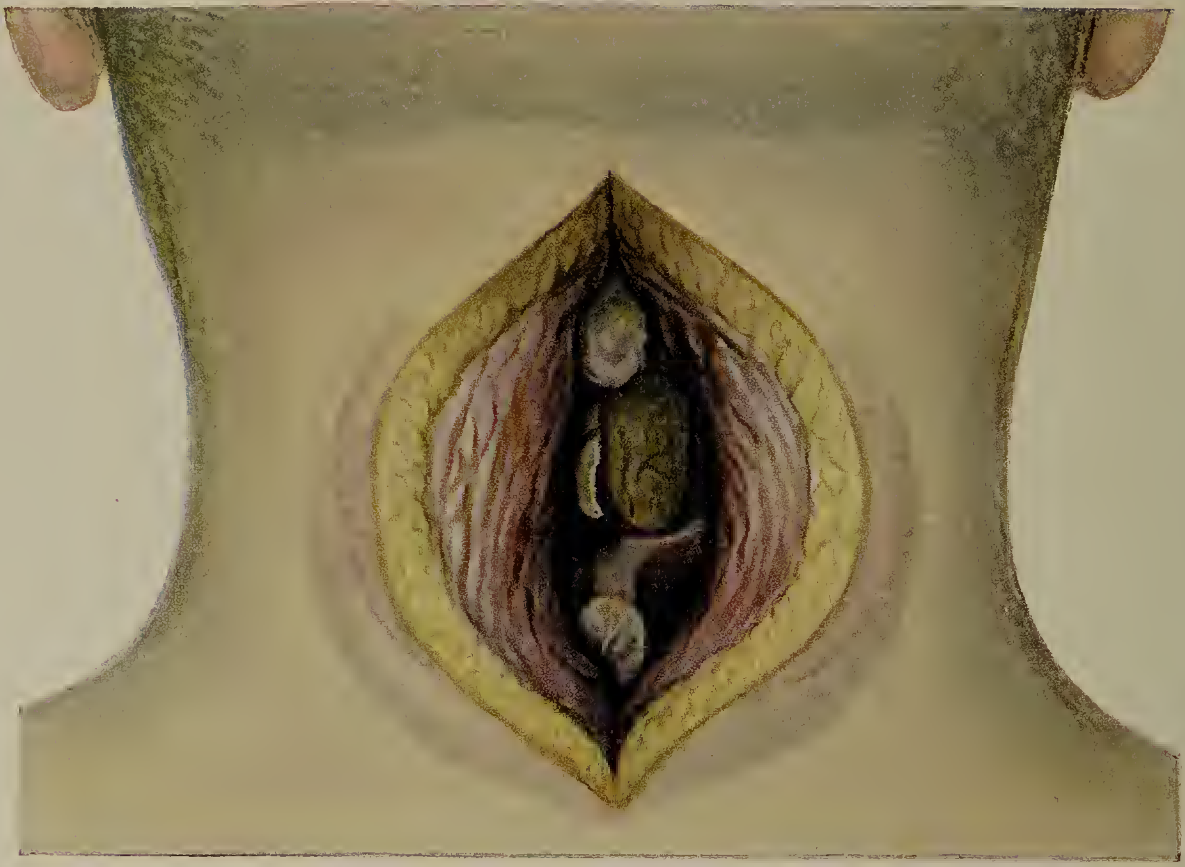


Fig. a.

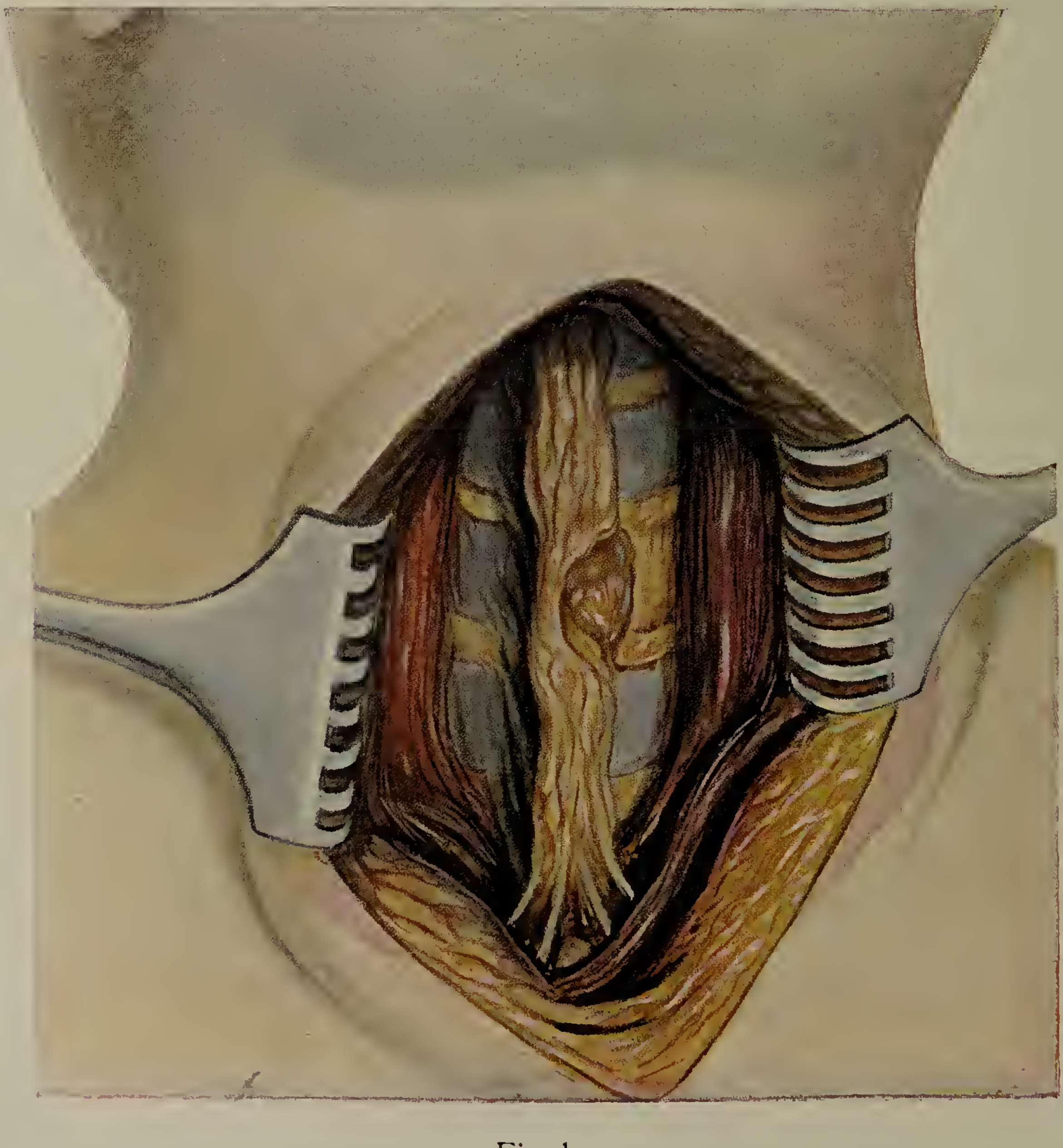


Fig. b.

Rebman Company, New York

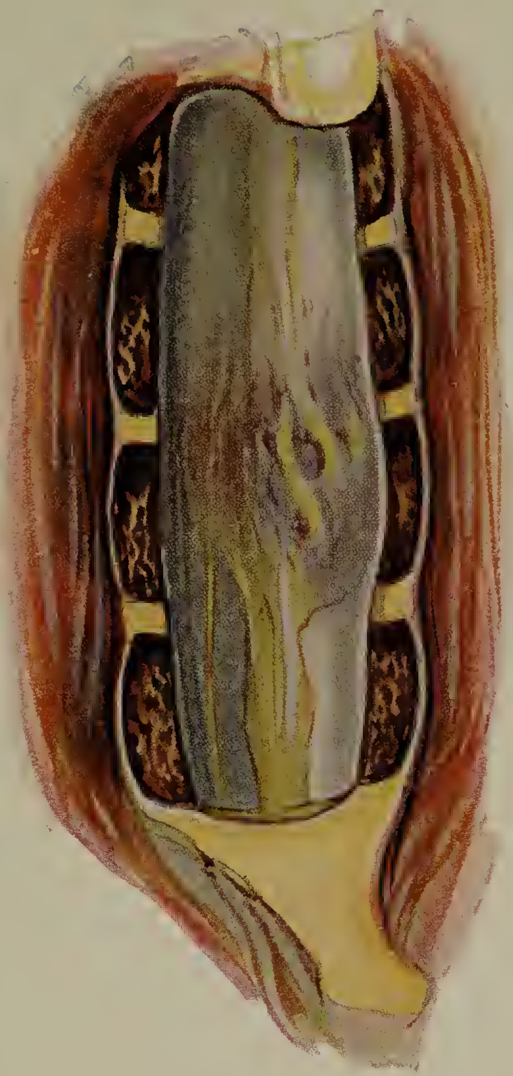


Fig. c.

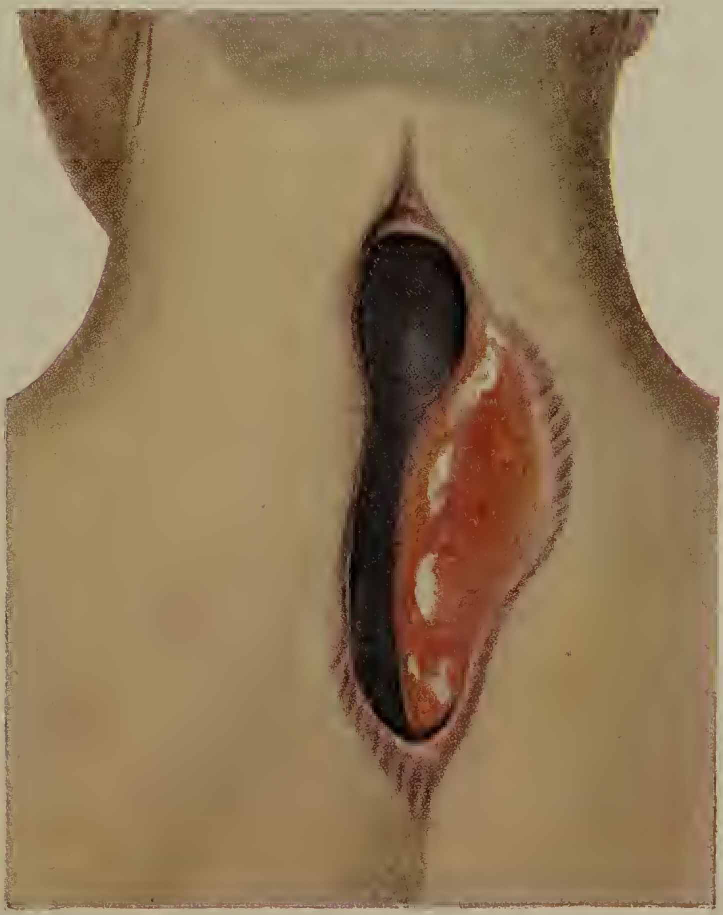


Fig. d.

down, the general condition of the patient began to suffer and his appetite and sleep were poor. In the beginning of November a slight swelling in the back of the neck was observed, which originated in the scar of the incision (the bullet was removed at his home), in the region from the 2d to 6th spinous processes of the cervical vertebræ. Even deep pressure was not perceived by the patient in this place, but pressing upon the right side of the cervical vertebræ caused pain. The movements of the neck were free, with the exception that the patient was unable to bring his chin to his chest to the same degree as before. It was evident that we were dealing with a process in the cervical portion of the vertebral column, in which the posterior roots of the cervical cord participated. Taking into consideration the occasional nocturnal rises of temperature to 38° C., and on the 1st of November even to 38.4° C., and the fact that the morning temperatures were subnormal (occasionally 36.2° C.), we concluded that the process was one of deep-seated suppuration in the vicinity of the old bullet-wound (5th cervical vertebra).

On the 2d of November the power of both lower extremities had suffered considerably. While the patient was able to lift his left foot to a height of two feet, and the movements of that foot and toes were considerable, he was unable to lift his right heel from the bed-sheet, and the movements of the foot and toes of the right lower extremity were minimal, the movements of the leg weak and extension fairly powerful. The knee-phenomenon was weak on the left side and on the right about normal. *Babinski* present on the left and three days later distinct on the right. The tests for sensation disclosed a hyperalgesia for pricks with the needle on the right thigh and the sole of the right foot; passing contacts on the left lower extremity with the cold test-tube showed no perception of cold. Flexion of the right forearm showed diminished power; pronation was better than supination, but incomplete. Opposition of the thumb was absent and flexion of the terminal phalanges was very weak. Abduction and outward rotation of the arm could not be executed. No paralytic manifestations were demonstrable in the region of the phrenic.

On the 5th of November the evening temperature was 39° C., and the pulse rose to 120 beats per minute. Since the general condition of the patient became rapidly worse, I exposed on the 6th of November the spinous processes of the 4th, 5th, and 6th cervical vertebræ by a longitudinal incision through the old scar. At the point where I separated the musculature from the angle between the spinous processes and the vertebral arches, 1½ to 2 tablespoonfuls of a thick, creamy, odorless pus came to view at the level of the 5th arch on the right side (see Plate LV, Fig. a). Four splinters of bone were found in it, which represented the right half of the arch of the 5th cervical vertebra shattered by the bullet and a semispherical cup of cartilage—evidently the cartilaginous covering of one of the articular processes. The 5th spinous process was mainly retained. As a result of the absence of half of the arch and the adjoining portion of the intervertebral disc, the dura lay exposed to an extent of a digit at the level of the 5th cervical vertebra on the right laterally to the median line; it was covered with pus and showed no pulsations. After careful evacuation of the abscess cavity and thorough cleansing, especially in the region of the dura mater, removing every portion that might exert pressure upon the cord, the most important indication had been met with and the operation was hurriedly concluded—on account of the collapsed condition of the patient—by tamponing the large wound-cavity with vioform gauze.

Four days later the temperature and, on the following day, the pulse also became normal and remained in that condition for fourteen days. The further result of the operation was the complete disappearance of the shooting pains in the shoulders and arms, and the spontaneous twitchings of the right arm and lower extremity recurred no more. After a transitory aggravation of the condition of mobility of the left lower extremity in the first two days after the operation, while the right lower extremity and both arms remained unaffected, the power of both extremities distinctly, but slowly, improved after the third day. The rapid onset of symptoms of exhaustion during the examinations was striking.

Twenty days after the operation the right leg could be extended with force, the thigh adducted and rotated inward, while movements of the foot and toes were still absent. These, as well as the movements of the hip and extension of the leg, were powerful on the left side. The knee-phenomena were normal on both sides. *Babinski* absent. The active mobility of the right arm was better and executed with greater power than before the operation. The sole of the right foot was hyperalgesic, and the musculature of the right calf very sensitive to pressure. There existed, as before, diminished sensation to cold. With reference to the condition of the wound, it was at that time granulating favorably, and distinct pulsations of the dura mater which was covered with healthy granulations were seen in its depth.

However, this favorable condition did not last. Two days later (28th of November), the active mobility of the lower extremities was weaker, and the knee-phenomenon could be elicited indistinctly on the right and on the left side. There was retention of urine after twenty-four hours, while, until that time, the patient evacuated his bladder without effort two or three times daily. The sensibility as well as the sense of position were the same as before.

Despite the healthy appearance of the wound, the temperature showed slight rises, and the pulse increased in frequency to 108 beats per minute. Everything pointed to a new process in the region of the cervical cord, which strongly influenced its conductivity. On the 3d of December the right lower extremity showed a complete and on the left an almost total paralysis. In the latter, only a weak, active flexion of the hip and still weaker extension of the knee joint were possible. The reflexes were entirely extinguished in the right lower extremity and on the left of all reflexes only a slight indication of *Babinski* was present. Hurry during the operation was, therefore, responsible for this condition. In order to relieve the cervical cord, I was compelled to expose the dural sac once more, but this time to a greater extent. I waited four weeks, during which time the condition of the patient improved to such an extent that I was able to operate again.

On the 4th of December the cicatrizing wound was enlarged longitudinally to the extent of a few centimetres above and below and the arches of the 4th, 5th, and 6th cervical vertebræ were completely exposed by detaching the musculature (see Plate LV, Fig. b). It was now seen that the left half of the arch and a part of the spinous process of the 5th cervical vertebra were preserved and that the right half (the place of which was filled with granulations) was present. This portion of the arch was of a grayish-yellow color and evidently necrotic, but even the left half of the arch was also abnormal, of a greenish-yellow hue, and the right halves of the exposed 4th and 6th arches were also changed similarly. In the substance of the bone of all of these affected arches numerous millet-seed sized, yellow, dry and necrotic spots were found interspersed. It was also striking to note that the depth of the wound was constantly bathed in a fluid only on the right side, while the left remained dry.

The remnants of the 5th and the entire arches of the 4th and 6th vertebræ were now removed close to their articulation. The inner surfaces of the left half of the 5th and the right half of the 4th and 6th arches were covered with these small necrotic spots. However, no granulation tissue nor pus was found between the arches and the dura. The exposed dura was covered with flat granulations at the point corresponding to the 5th arch, after the removal of which the dura was found markedly infiltrated with pus and so discolored that we apprehended a beginning necrosis (Plate LVI, Fig. c). Had this been true, the patient would have undoubtedly succumbed to a purulent meningitis. Fortunately, however, the dura recovered in the further course of the disease. Springing from this changed area, purulent infiltrations and red spots were seen extending upward and downward on the right side into the cleft of the bone to a considerable extent. At the lower portion these changes ceased close below the upper margin of the removed 6th arch, and they extended so far above that I was compelled to remove the arch of the 3d cervical vertebra in order to find normal conditions. This extensive exposure of the dura was successful in bringing to view small areas of normal-looking dura at both angles of the wound.

The following most peculiar conditions (see Plate LVI, Fig. c) were found upon the exposed sac of dura to an extent of 7½ cm. Its form was distinctly spindle-shaped, with the greatest point of enlargement corresponding to the defect in the arch of the 5th vertebra, bulging especially toward its right side. At this point, and for a distance of about 2 cm. upward and downward, it was very tense and did not show a trace of pulsation, not even during the entire further course of the operation, which lasted at least an hour. Only the last centimetre of the upper angle of the wound showed distinct pulsations, which were also barely perceptible at the lower section of the wound. The palpating finger discovered everywhere considerable fluctuation, but no accumulation of liquor.

In order to make sure that there existed no suppurative-necrotic process on the anterior surface of the dura, between it and the bodies of the vertebræ, I investigated it with two half-pointed, curved elevators from right to left in such a manner that both instruments met in front and the sac of dura was lifted somewhat outward. This manœuvre was carried out on two places above and below the suppurative infiltration extending to the right, the lateral limits of which could not be reached even after total removal of the arches. The sac of dura was easily detached, and from its anterior surface only a slight quantity of fluid was drained off.

Since the suppurative infiltration extended toward the right side to the base of the removed arches, and in order not to overlook any focus that might, perchance, be hidden, the periosteum and soft tissues on the right side were detached from the transverse processes until the nerve trunks issuing from the intervertebral foramina were exposed to an extent of about 3 mm. Nothing pathologic was found.

At the conclusion of the operation the marked tension within the sac of dura had somewhat decreased and the pulsations were not changed to any degree. The entire wound was tamponed with iodoform gauze.

The course after the operation was nearly afebrile (a few evenings 38° C.), and the frequency of the pulse decreased within five days from 124 beats to about 88 to 96 beats per minute, and after five more days to 76 to 84; at the same time it became fuller. Despite the extreme weakness of the patient, the movements of the arm and of the left lower extremity were not aggravated after the operation. The patient had to be catheterized only on the evening after the operation. On the first few days he urinated spontaneously only once a day, and after the 10th of December this act could be accomplished twice daily and without difficulty, and from the 26th of December on, occasionally also three times a day. Even in the further course of the disease disturbances were observed in this respect; for instance, on the 17th of January and on the 12th and 19th of February, retention took place, lasting from twenty-two to twenty-five hours.

The first improvement in the movements were observed sixty hours after the operation and the patient was able to rotate his right lower extremity inward to a very slight degree; up to that time it lay flaccidly immobile in outward rotation. On the following day I was able to elicit the patellar reflex on the left side, and on the 10th of December a trace of it was discovered on the right side, but at this time it disappeared from the left again. At the change of dressings on the 12th of December the dura showed pulsations in the entire extent of the wound with the exception of a small place on the right side, i.e., the site of the purulent infiltrations. The pulsations in this place were slight, but healthy granulations appeared to develop. Palpation showed the dura to be everywhere of the same soft consistency.

In order not to make the description of this case too lengthy, I will omit the detailed report of the gradual return of the reflexes and the active movements. I will say, however, that they recurred very slowly and under great fluctuations, and that exhaustion soon set in during the examinations.

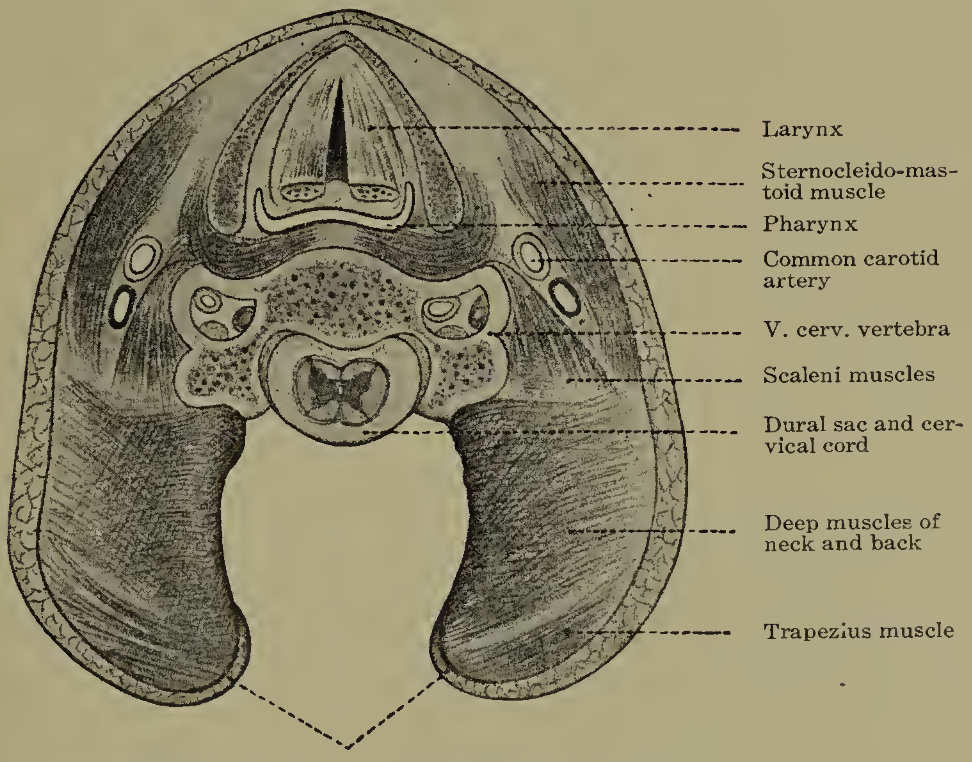
Four weeks after the operation the entire wound-cavity was in a healthy granulating condition, and at the borders of the wound cicatrization began (Plate LVI, Fig. d). In this state of affairs the wound would hardly heal, for there existed, as in cases after sequestrotomy in the femur, a cavity, in the great depth of which the dura, covered with sparse granulations here and there, lay exposed in the form of a blue cord (see Fig. 175). In the further course of cicatrization the epidermis would have grown on to the dura mater, which would not protect it in the least from insults of various sorts, and the patient would be in constant jeopardy of developing a meningitis upon the slightest injury. I therefore freshened the borders of the wound on the 2d of January, 1906, undermined the soft tissues laterally and united it over the dura mater in a number of layers. Healing resulted without any disturbance, and the scar, measuring 13 cm., extended upward to the border of the hairs (see Fig. 176).

On the 7th of January the patient was able for the first time to lift his left heel from the bed-sheet when in a lying position to a slight degree, and he was also able to rotate his right lower extremity inward and outward.

On the 9th he was able, when in a sitting position, to elevate his left leg and bring it into a position of extension and the right one to an angle of forty-five degrees. He had been unable to do this for a number of months. He was also able to flex the left foot dorsalward, while with the other foot he could not accomplish these movements and in which there still existed a total paralysis of the extensors; the latter was only noticeable of late.

Fig. 175

Schematic Transverse Section at the Level of the Fifth Cervical Vertebra.


Larynx
Sternocleido-mastoid muscle
Pharynx
Common carotid artery
V. cerv. vertebra
Scaleni muscles
Dural sac and cervical cord
Deep muscles of neck and back
Trapezius muscle

Beginning epidermization of the deep granulating wound cavity

The knee reflex was present on both sides, and on the left side the *Oppenheim* reflex was slightly present and the *Babinski* phenomenon was distinct. On the 23d, *Oppenheim* could be elicited on the right side also, and, a few days preceding, the toes of the right foot could be moved actively to a limited degree. On the 28th of January the patient undertook to stand up for the first time, and when supported on both sides he was successful.

On the 9th of February, 1906, he departed for home. The movements of his neck were free and without pain, and he was able to sit up in a chair, mornings and afternoons, for an hour, during which he kept his head free. He was of jovial mood, slept well, and became considerably stronger. On the 3d of March he was able to stand up for the first time unsupported, but for a few seconds only. Toward the end of that month he could walk through the room when led by his sister. At the

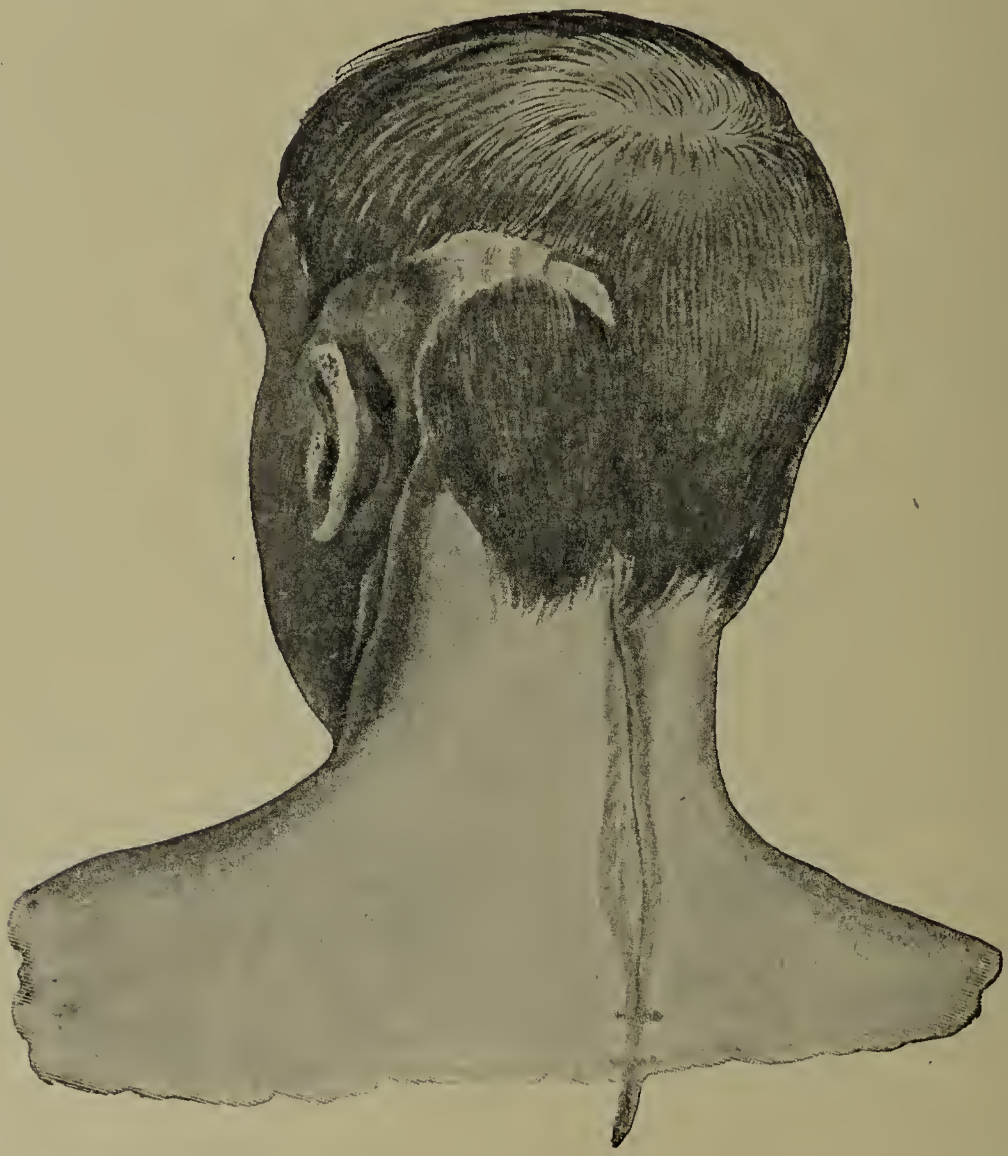


Fig. 176

same time his lower extremity recuperated to such an extent that, when in dorsal decubitus, he could elevate it high with an extended knee. The peroneal group was at that time still paretic.

In May, 1906, the general condition of the patient was excellent and he was able to walk 100 steps in succession. The exhaustion was due to the weak condition of his lower extremities, but he wanted to sit down because the erect position of the head caused him unpleasant sensations. Gradually, however, all the functions which were interfered with by the incomplete *Brown-Séquard's* paralysis were restored to an extent as before the serous meningitis resulted in an almost complete interruption of conduction. In the Fall of 1907 the patient could walk with the aid of a cane, and he was perfectly free from disturbances, in blooming health and mentally very active.

On Christmas, 1907, he wrote me a long letter, in which he informed me of his satisfactory condition. This continued until November, 1908, at which time his physician wrote that febrile manifestations had appeared, which were diagnosed as influenza. In January, 1909, two attacks of aphasia set in, which were accompanied with violent pains in the left eye. About the end of March the symptoms pointed to a cerebral abscess, the temperature became elevated, and the patient died on the 4th of April, 1909, with an aggravation of all symptoms. No postmortem examination was made. All indications, however, pointed to a flaring up of suppurative processes within the cranium, which were subdued at my first operation on the 8th of July, 1905, and which have evidently at this time culminated in a cerebral abscess. Physicians treating him at that time advised an operation, which the patient or his relatives declined.

The paralysis found at that stage of the disease of the spinal cord during which the operation was performed (on the 4th of December, 1905), was caused by a meningitis serosa. This, again, was occasioned by the suppurative-necrotic osseous process on the arches of the vertebræ. The continuous dribbling of the œdematous fluid from the depth of the wound during the operation, limited to the right side, was analogous to the serous meningitis observed in suppurative conditions of the ear, in which the inflammatory œdema is brought about by extension from the suppurative changes in the dura mater. The peculiarity in this respect was the limitation of the intradural accumulation of fluid under high tension, principally in the region of the diseased arches of the vertebræ, especially on the right side at the level of the 5th. The change was so distinct that the artist, sketching during the operation, was able to retain it in the picture.

The operation further disclosed the fact that despite the rapid appearance of manifestations of severe compression of the spinal cord, no extradural process restricting the space within the vertebral canal was found. At the first operation (6th of November) I found a quantity of pus deep below the tense, soft tissues, and immediately upon the dura, which could have undoubtedly caused compression of the cord. After complete evacuation, however, the manifestations of compression disappeared, to recur in a more aggravated extent after the twenty-second day following the operation.

At the second operation (4th of December) the analogous findings could in no way have been brought about by the accumulation of granulation tissue. The severe damage to the cord was produced by substances exclusively within the dura, as shown by the high tension of the dura and by the absence of pulsations. It was no doubt a liquid, as disclosed by the presence of fluctuations. I dared not puncture on the same day for fear that the septic conditions of the operation field might invite infection of the soft coverings of the spinal cord, which would bring the patient into danger. Puncture of the dura was performed after the change of dressings following the action of iodoform gauze for three days. It was then punctured in two places, and liquor cerebro-spinalis of a watery color slowly dribbled away. Intradural pressure had considerably lessened within three days, and the sac appeared more flaccid and was pulsating in its entire extent.

The irregular affection of the various tracts was a remarkable fact in this case. The sensibility, including the joint-sense, was not reduced, and the musculature of the right calf even hypersensitive to pressure; the decreased sensibility for thermic stimuli of the left lower extremity was undoubtedly brought about by the old *Brown-Séquard* paralysis. The ability to move the right lower limb was totally, and that of the left almost completely, extinguished, and the reflexes had disappeared.

Indurations of the Spinal Cord (Meningitis Fibrosa Chronica)

The affection of the cervical portion of the spinal cord has for a long time been known under the name, coined by *Charcot,* **pachymeningitis cervicalis hypertrophica.** The older authors designated it **meningomyelitis cervicalis chronica,** and recent observers also prefer this name,[1] while the spinal cord itself is usually affected in the form of isolated foci and diffuse inflammatory processes. Of the spinal membranes, not only the dura alone is involved, but the soft coverings as well suffer; in some cases even to a greater extent than the former. Up to the present time this disease is of no surgical interest. I must mention it, however, for the reason that in four cases in which the diagnosis of an intradural space-restricting process or a neoplasm of the spinal membranes was made, and in another (fifth) doubtful instance (see Observation XV, 4, p. 1121) changes were found which in certain respects resembled those observed in pachymeningitis hypertrophica cervicalis.

All of my observations concerned the thoracic cord. The normally separated condition of the membranes was obliterated and they were fused into one indurated mass, and the arachnoid spaces in the diseased portions had mainly disappeared. A firm fibrous induration, a few millimetres thick, adhered to the substance of the spinal cord, which could not be bluntly detached from it, and, in order to separate it, cutting instruments had to be used, during which crepitation of the hard masses was audible. In one of my operations I also found that in isolated places of the affected region the anterior surface of the resected arches of the vertebræ and the ligamenta intercruralia (flava) were closely united with the induration, so that it was not always possible to introduce a pointed elevator between the two and that the arches had to be broken off piecemeal with the rongeur forceps.

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[1] *J. M. Wieting, Ziegler's* "Beiträge zur pathologischen Anatomie." Vol. XIX, p. 207.

One of the patients died twelve hours after the operation from bilateral pneumonia and the post-mortem examination made by *Professor Oestreich* disclosed the exact conditions.

OBSERVATION XV, 1

Diagnosis of Probable Extramedullary Tumor of the Sixth or Seventh Thoracic Vertebra. The Operation Disclosed a Firm Induration United with the Spinal Cord.

The patient was a girl, twenty-three years of age, in whom *K. Mendel*[1] and *H. Oppenheim* made a diagnosis of probable extramedullary neoplasm seated on the left side at the level of the 6th or 7th thoracic vertebra. This was not found during the operation, but in its stead a firm fibrous induration closely united with the spinal cord. Apparently normal conditions were found above and below it only after the removal of the arches of from the 4th to 9th vertebræ. The altered dura was split longitudinally in the median line and separated from the widely opened vertebral canal. It was closely united with the cord and with the inner surface of the arches.

The indurated transformation of the membranes of the spinal cord extended upward to the lower border of the arch of the 5th dorsal vertebra and, from that point on, the dura showed a normal appearance with the exception that at the level of the 5th arch it looked as if constricted. On the 7th arch granulations were still visible in the induration which ended below, above the upper border of the arch of the 9th dorsal vertebra, so that its entire length was 96 mm. It was much more developed on the left than on the right side, and its greatest thickness, which corresponded to the 6th arch, was about 6 mm.

The post-mortem examination showed the dura to be adherent to the entire field of the operation and sides of the spinal cord from which it could not be detached bluntly, while in the front it was somewhat thickened but detachable in the usual manner. Above the portion exposed by the operation it appeared thickened to the length of 4 cm. on the posterior surface and it could be bluntly detached. The morbid process therefore was principally limited to a circumscribed area at the posterior section.

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[1] Compare *Kurt Mendel,* Meningomyelitis unter dem Bilde eines Rückenmarkstumors. "Berl. klin. Wochenschr." 1909, No. 50.

The total removal of the spinal cord, together with the dura, was easily accomplished, and no union was discovered between it and the bones. Specific changes (tuberculosis, syphilis, osteomyelitis, etc.) were also absent. Section of the bodies of the vertebræ showed perfectly normal conditions, and the periosteum was also unchanged. No tuberculosis was found in the internal organs.

Microscopic examination of the removed tissues showed them to consist principally of fibrous make-up, poor in nuclei (induration). In some places young granulation tissue, rich in cellular elements with isolated aggregations of mononuclear small round-cells and larger ones with pale nuclei were seen. No tubercle, giant-cells, or necroses were present. Examination for tubercle-bacilli was negative. There were also no changes in the blood-vessels and no tumor-tissue.

Professor Oestreich was of the opinion that the induration does not possess a specific character. However, tuberculosis could not be entirely excluded.

In my other cases the severe paralyses of the spinal cord were shown by the operation to be occasioned by compression exercised by the firm indurations affecting dura, arachnoid, and pia alike. The substance of the spinal cord suffers as a consequence of the pressure exercised by the contraction of the connective-tissue mass. In certain places we have even found constrictions that were evidently due to cicatricial contraction. The clinical manifestations have, therefore, resembled in many respects those of intravertebral neoplasmata and even experienced diagnosticians, who have referred the patients to me for operation, were forced to make a probable diagnosis of tumor from the symptoms presented.

However, the spinal cord does not only suffer from the pressure alone, but the morbid process in the form of fibrous new-formations extends even into its substance, as I have seen it occur in two operations. In one case (Observation XV, 2) a focus of softening was opened in the posterior region of the spinal cord, while in another instance (Observation XV, 3) a sort of cyst-formation was discovered.

In the above-mentioned patient, who died of pneumonia, the spinal cord was examined microscopically by *Messrs. Bielschowsky* and *K. Mendel.* The severe inflammation of the spinal membranes continued deeply into the substance of the cord (meningomyelitis). The process extended in an upward direction, gradually decreasing to the level of the 4th dorsal segment. All membranes in the diseased area were transformed into a firm, thick induration which in some places measured about 1 cm. in thickness. Between the connective-tissue strands of the pia mater and within the meshes of the arachnoid, islands of granulation tissue, poor in vessels, were present to a greater or less extent, which showed in some regions a marked tendency to the formation of fibrous intercellular substance. Transverse section of the spinal cord at a point corresponding to the greatest inflammation showed it to be very œdematous. Marked proliferation of the endothelial cells of the vessels were found in many places. Giant-cells were entirely absent and real tumor-tissue could be found nowhere.

With reference to the nature of the inflammatory process, tuberculosis could be excluded. However, there exists a great suspicion that the process was of a syphilitic nature. This view was supported by the characteristic changes in the vessels and the marked development of fibrous tissue at the peripheral zones within the regions of granulation. A positive diagnosis of the specific nature of the process could not be made, even after microscopic examination.

Operative exposure always showed the normal pulsations of the dura to have disappeared, and in no case were they visible to the naked eye. In most instances they could not be felt with the finger. (This was successful only once.) In two instances accumulation of liquor was found above the induration. This was responsible for the marked fluctuations in the symptomatology, especially in ascertaining the upper level of the disease which rendered a diagnosis extremely difficult.

Since we were dealing with a chronic inflammatory process, it would be natural to assume that the patients would complain of local pains. Percussion of the vertebral column or pressure upon the spinous processes, however, was perceived as painful in only one of our cases. The movements of the trunk were always free to all sides, and there was no gibbus. In one case the vertebral column was found scoliotic when the patient was standing. This was due to the fact that he supported himself exclusively on the non-paralyzed lower extremity and by so doing brought the trunk into that position.

Lues, tuberculosis, and chronic osteomyelitis may be mentioned as **etiologic factors.** In one case (Observation XV, 2) a secreting fistula which led to the 10th rib rendered an assumption of tuberculous disease justifiable. However, the bones of the vertebral column have always been found sound or, at any rate, not much affected at the time of the operation.

Treatment of Meningitis Fibrosa

The induration should be split in its entire length at the operation on the diseased dura mater and entirely removed wherever possible; for it restricts the space in the vertebral canal like a tumor and constricts the spinal cord. It is best to split it with a knife in the median line after its upper and lower limits have been freely exposed and after it has been lifted slightly upward by grasping it with rat-tooth forceps. My experiences teach me that careful dissection, dividing layer after layer, and noting the difference in consistency of the structures divided, will prevent the danger of injuring the soft cord. In some places, especially at the point of transition from the altered to the normal dura above and below, the induration is found to be divided from the cord by a few drops of liquor and in some instances (in two of our cases) an abnormal accumulation of cerebro-spinal fluid at the upper end was present. The thickness of the induration is variable at the different levels of the morbid process.

Splitting of the induration alone is, in my opinion, insufficient. Its extirpation exposes the tissues we wish to examine, discloses constriction of the cord, if present, and permits the attack of foci of softening and cyst-formations when found. I have abandoned the operation after splitting in only one case—the first one I have operated upon—(Observation XV, 4), and this was done on account of the extraordinary extent of the affection (covering seven vertebral arches) and on account of the extreme weakness of the patient.

We now proceed from the median incision to dissect the diseased membranes from the cord in the form of two long strips, which is accomplished in some places bluntly and in others with the knife. The excision laterally must be as extensive as the total resection of the vertebral arches will permit. The induration is not only recognized by its firm consistency but its brownish-yellow or reddish color, and at times also its white cicatricial nature will help to distinguish it from the light-yellow color of the cord.

The attempt to introduce a fine probe between the induration and the spinal cord, and to split the former upon it, is to be condemned. The fact that there exists in most places firm union between these structures, the introduction of the sound and even the most careful palpation with it, may cause the probe to easily enter the soft substance of the cord and give rise to severe injuries. Of course, occasionally, we may be successful in this practice, as in one of my cases (Observation XV, 2) I was able to introduce a delicate probe on the sides of the induration in the space between it and the spinal cord, and to divide it; but in this case a normal strip of dura mater, laterally to it, was visible.

In one of the autopsies referred to above, the dura was involved principally in its posterior extent. Should the induration extend to the front of the cord, we, of course, will limit ourselves to the excision of that portion posteriorly made accessible by laminectomy. The spinal cord will then have room to avoid the constricting pressure. After completed operation it is covered by the sutured musculature of the back, and the space is rendered wider by the removal of the arches and the spinous processes, and is much greater than normally. The anterior portion of the dura can only be reached by lifting the cord upward, and the eradication of the morbid process occasioned by indurations would be by far more difficult than even the removal of a circumscribed neoplasm in this particular anatomic locality. I was successful in such extirpations twice by carefully displacing the cord and by the removal of three thoracic arches (compare Observation XVII, 1, p. 1140).

A fact I have observed in one of my cases, which I consider of importance, is, that a longitudinal incision into the cord made exactly in the posterior commissure will, if carefully executed, not necessarily be followed by serious disturbances.

Prognosis

The morbid manifestations occasioned by pachymeningitis hypertrophica are not always improved by an operation, and in one case (compare Observation XV, 3) it was followed by an immediate aggravation. In other cases again, the sensory disturbances completely disappeared, while the spasms and paralyses were only slightly changed; and in still another case the motility improved to a considerable degree. However, the nature of the disease does not permit us to expect a permanent cure, and the improvements noticed in the beginning are not always lasting, for it has been shown above that the cord itself participates in the chronic inflammatory processes. This has been established with certainty in *Mendel's* findings. Furthermore, during one operation I found a focus of softening and, at another time, a cystic degeneration within the substance of the cord. Consequently, we must not entertain hopes of complete cures but be satisfied if we get improvement in the condition of the patient.

In this respect also neoplasmata of the membranes of the spinal cord are fortunately entirely different from indurations. Intradural tumors originate, in the majority of instances, from the inner surface of the dura or from the arachnoid; they do not become adherent to the spinal cord; they injure it by increasing pressure. In these cases, as pointed out by the various observations, I was successful in seeing complete restoration even in cases of severest paralysis of the lower half of the body, and also where the upper extremities have become involved.

To illustrate the rarity and limited knowledge of these conditions, I will cite three of my observations.

OBSERVATION XV, 2

Manifestations of Intravertebral Tumor-Formation. Induration of the Cord Corresponding from the Sixth to the Eighth Arches of the Dorsal Vertebræ. Improvement Continuing for Two Years Following Excision and Opening of an Intramedullary Focus of Softening.

A woman, fifty-one years of age, began to suffer, one and a half years prior to coming under our observation, with a girdle sensation and pulling pains in the region of the coccyx, which was followed by the same sensations in the lower extremities, to which a sense of numbness developed in both feet. Six months later, standing and walking were impossible. Spasmodic twitchings were observed in the left lower extremity, and urination could only be accomplished with extreme effort and pressure of the abdominal wall. A girdle-form sense of tension was also complained of in the region of the umbilicus.

Geheimrat Ziehen made a diagnosis of an intravertebral neoplasm-formation, the seat of which (intra- or extra-medullary) could not be ascertained.

When the patient was admitted to the Augusta Hospital (August 30, 1907), a spastic paraplegia and bilateral reduction of the sensibility for all qualities was found on the left side anteriorly to about 3 cm. above the arch of the ribs and posteriorly to the angle of the scapula; on the right anteriorly to the 9th rib, and posteriorly to the 12th.

No other organs showed pathologic findings. A slightly reddish scar was found below the right breast, in the centre of which a small fistulous opening was discernible, into which no probe could be introduced. The patient gave a history that at the age of seven she fell from a chair and injured some of her ribs. At the point of injury an abscess developed, from which a few pieces of bone suppurated away. The opening was closed, but opened again about a year ago. The vertebral column was not at all sensitive.

On account of the disturbances of motility and sensibility I suspected a space-restricting process within the vertebral canal at the level of the 7th dorsal segment. The operation was per-

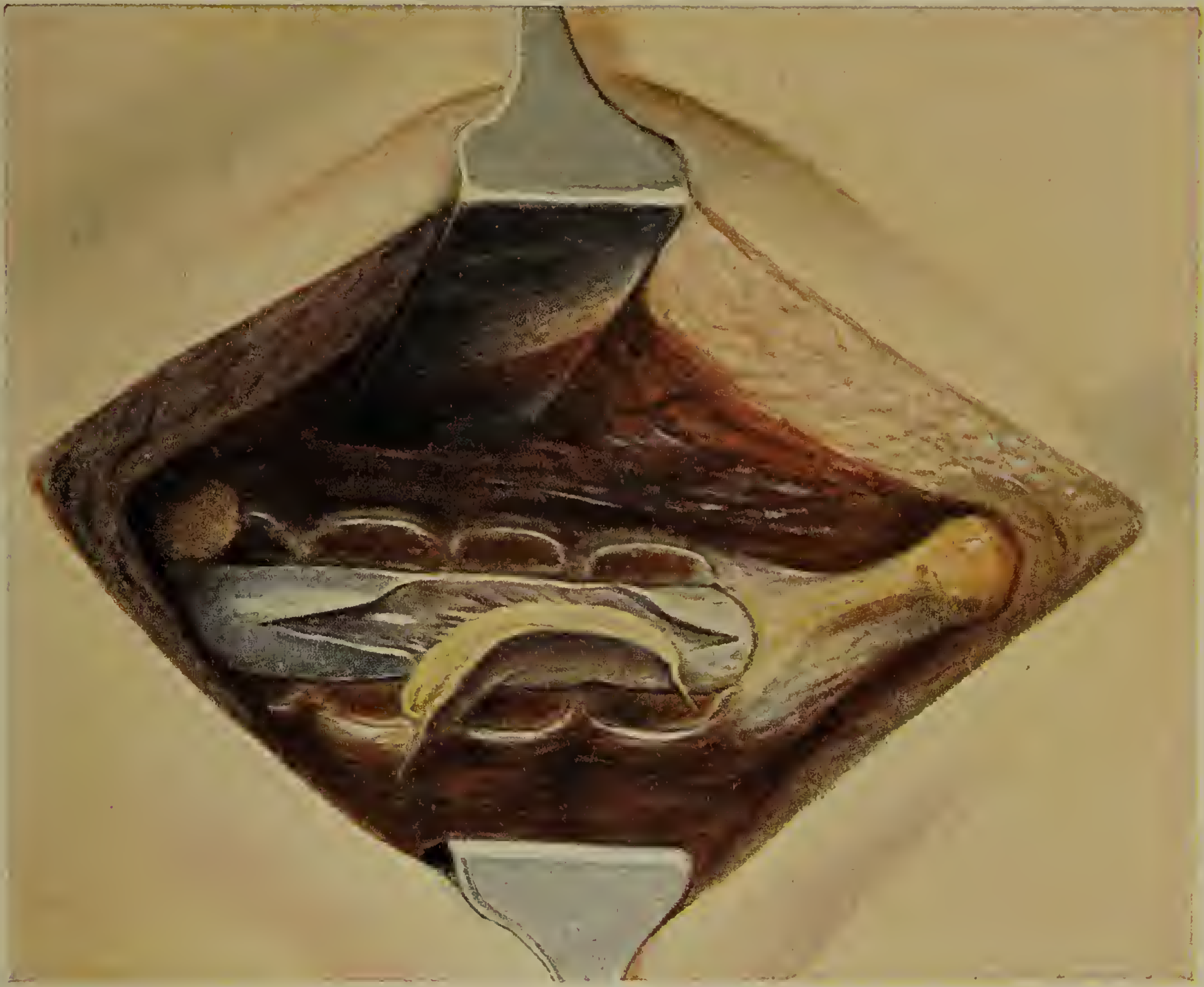


Fig. b.

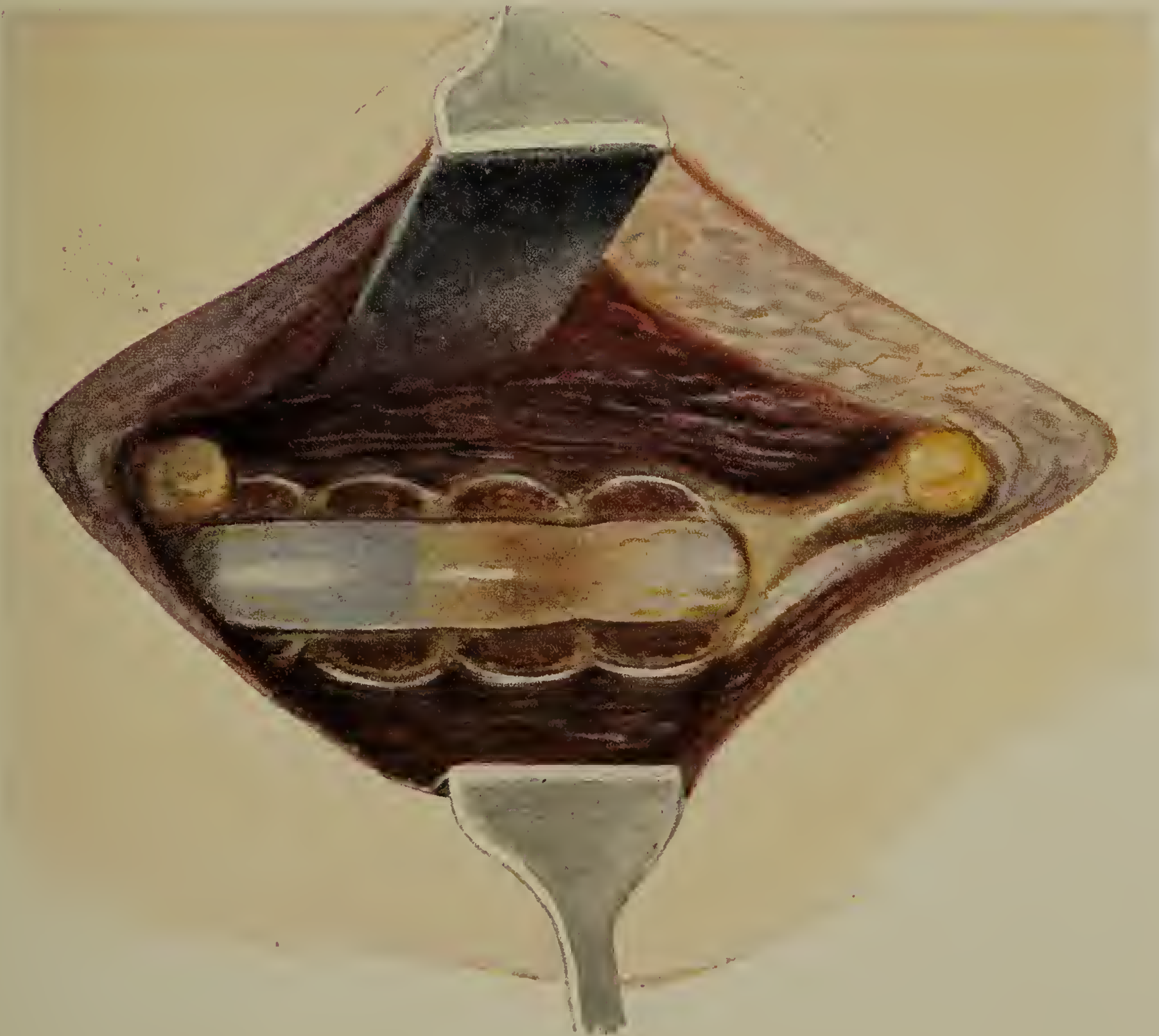


Fig. a.

formed on the 24th of September, 1907, and the arches of the 5th to 8th dorsal vertebræ were removed. A firm brownish or yellowish-red-looking induration was found extending from the middle of the 6th to the 8th arch, while at the upper and lower angles of the osseous cleft the normal-looking and pulsating dura came to view (compare Plate LVII, Fig. a). Within the thickened portion of the dura palpation perceived slight pulsations, but they were not visible in this situation. From the incision of the dura above the induration only a slight quantity of liquor drained off. A probe introduced intradurally could not be pushed backward, but it was possible to project it to the right and to the left without obstacles. The induration was divided only in these two places by grasping the lower portion of the dura with a tenaculum and separating it from the cord with the knife (compare Plate LVII, Fig. b). The excised section was 48 mm. long, 10 mm. wide and 4 mm. thick. Since the exposed posterior sur-

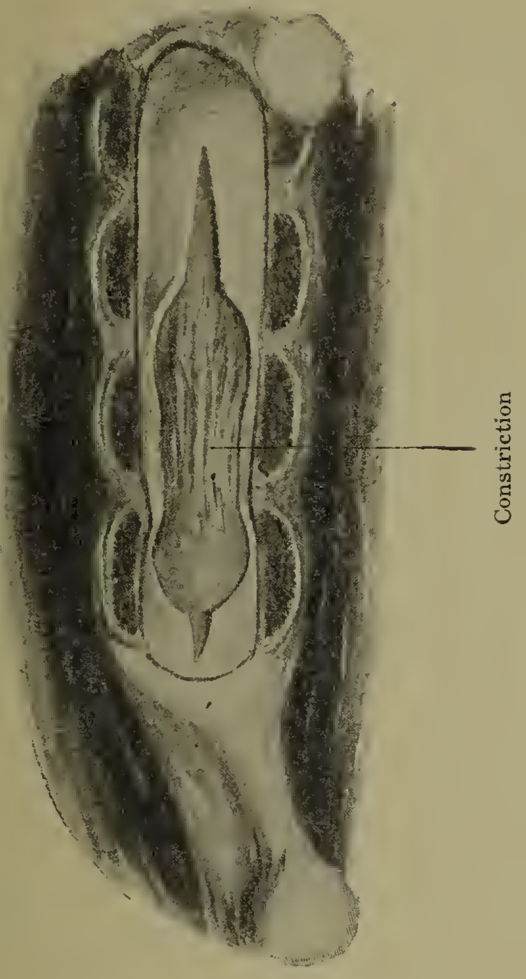


Fig. 177

$\frac{3}{4}$ natural size

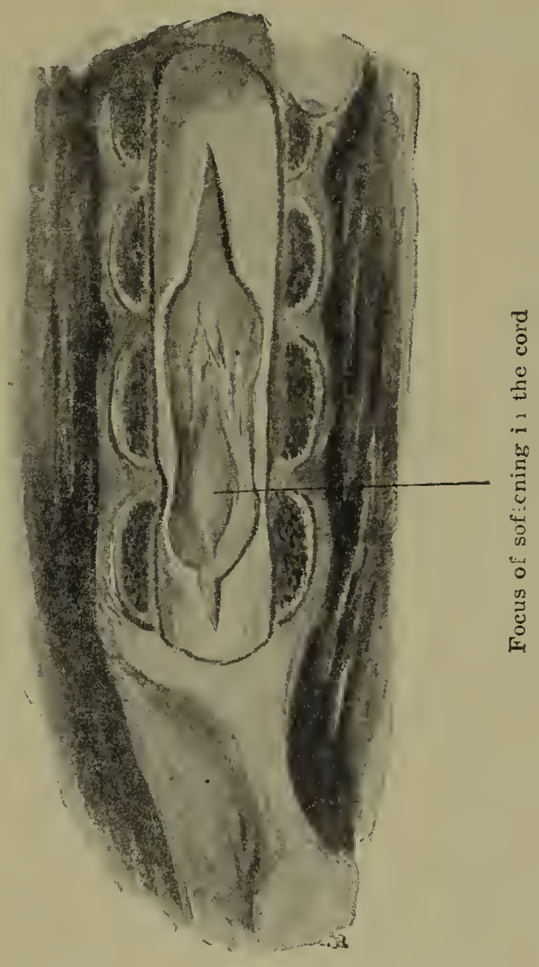


Fig. 178

face of the cord at the level of the 7th arch appeared constricted by the hard fibrous masses (see Fig. 177), a longitudinal incision, 2 cm. in length, was made with a knife into the posterior commissure with the greatest possible care. At a depth of about 2 mm. this led into a focus of softening, at least the size of a pea, from which a grayish-brown, grumous liquid was evacuated. The muscles and skin were finally sutured without drainage, and they healed within a month.

In view of these findings on the spinal cord, I thought the patient lost, but the case proved the contrary, and while until the day of the operation the urine had to be taken from her with a catheter, immediately after its performance she was able to urinate spontaneously. On the fifth day a slight improvement was noticeable in the paralyses of the lower extremities, especially on the left side, and the knee-joint could be actively extended to a slight degree. The ankle-joint and toes could also be moved actively to a limited extent. In the following two weeks the spasms also decreased. The sensibility and the exaggerated reflexes, however, were not changed.

During the next four weeks marked improvement was noted in the condition of the patient. Passive extension and active movements of both lower extremities, especially of the left, became more extensive from week to week, and the lightninglike twitchings did not occur as frequently as before. The general condition of the patient improved visibly. Five weeks after the operation she was able to move her bowels voluntarily. Three weeks later the temperature sense began to reappear in the lower half of the trunk, but the other sensory qualities were still absent. At this time almost all movements could be executed with both lower extremities weakly, of course, and to a restricted extent; the spasms had considerably decreased.

At Christmas, 1907, the patient was able to walk on crutches, but the weakness in the knees was still marked. She was discharged from the hospital a month later, and her general condition was at that time splendid.

An examination made on the 4th of November, 1909 (two years after the operation), showed the following conditions: Her physical condition was excellent and she was well nourished. Her lower extremities had of late considerably improved in power, so that she was able to stand up with slight support. She stated that, when sitting for considerable periods, she perceived pains in the lower extremities, which disappeared in the recumbent position and after a rub-down with spirits of camphor. She frequently perceived tenesmus, but never urinated involuntarily; fecal retention was normal.

The scar of the operation on her back was not attached to the underlying structures and was slightly sensitive in its lower portion. Head and arm could be freely moved in all directions. It was stated that when she forcibly lifted the left arm, involuntary movements in the left knee and ankle-joints would occasionally occur. She was able to sit in a chair without the slightest support.

When the patient was reclining, her hip and knee joints were in slight flexion and the feet were in a position of adduction. When in dorsal decubitus, she was unable to lift or extend her lower limbs from the bed-sheet. When sitting on the edge of the bed, however, she was able to lift the leg with some power. She could also flex both lower extremities at the hip and knee joints actively, i.e., the left limb to maximal flexion and the right to a little more than a right angle. While executing these movements clonic twitchings would occasionally set in. The ankle and toe joints were actively freely movable.

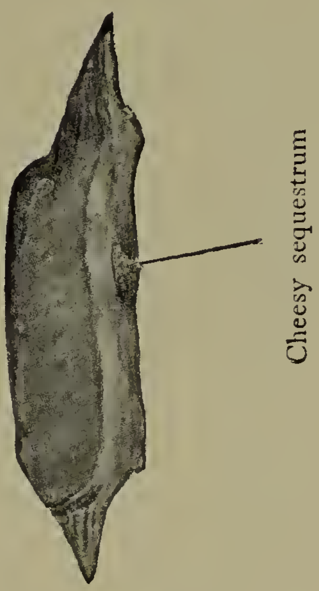


Fig. 179

The sensibility of the arms and the trunk was normal in the front and posteriorly to the level of the scar. After this, a zone was found on the back, the length and width of which corresponded to the scar, in which contacts with the brush were not always perceived. The sense of pain and temperature sense were, with the exception of the immediate vicinity of the scar, retained. Farther down, however (about a hand's breadth below the umbilicus), as far down posteriorly as the 10th spinous process, the patient did not perceive contacts with the brush, neither on the trunk nor on the lower extremities, and there were also everywhere in this region hypalgesia and therm-hypæsthesia. Pricks in the gluteal region were perceived in the leg or foot. Localization on the extremities, especially on the right, was entirely erroneous.

Slight spasms were observed on both knee and ankle joints. The reflexes were that much improved, that the ankle-clonus and the *Babinski* and *Oppenheim* phenomena were much milder on the left side, while on the right they persisted as before. The patellar reflex could not be elicited on the right side on account of the existing spasms, but on the left it was present. The abdominal-wall reflexes were absent.

With reference to the morbid process, we were dealing in this case with tuberculosis. The careful examination of the exposed parts of the vertebral canal did at no place disclose any pathologic findings, but a cheesy sequestrum, about 3 mm. in length (see Fig. 179), was found in the excised induration, which upon microscopic examination disclosed a number of smaller sequestra imbedded within the callosity. The capsule of such a loose sequestrum was incised. Microscopic examination further showed that the specimen mainly consisted of cicatricial tissue, poor in vessels, and in the meshes of which granulations were present. Within the granulation tissue, especially at the borders, foci with central necrosis were observed, resembling tubercular tissue. They were grouped in masses and contained no giant-cells. Some of these tubercles were in an incipient stage of cicatrization (fibrous tubercle).

OBSERVATION XV, 3

Suspicion of an Extramedullary Tumor in the Upper Thoracic Portion. Induration Extending from the Sixth to the Eighth Arches of the Dorsal Vertebræ, with Liquor Tension Above. Excision. Opening of a Cyst within the Substance of the Cord Followed by Considerable Aggravation of the Paralyses. Later on, Considerable Improvement, Continuing for Two Years.

The patient in this case was a physician, forty-one years of age, of powerful build, who began to suffer in January, 1905, with pains in the lumbar region. In April he was seized with

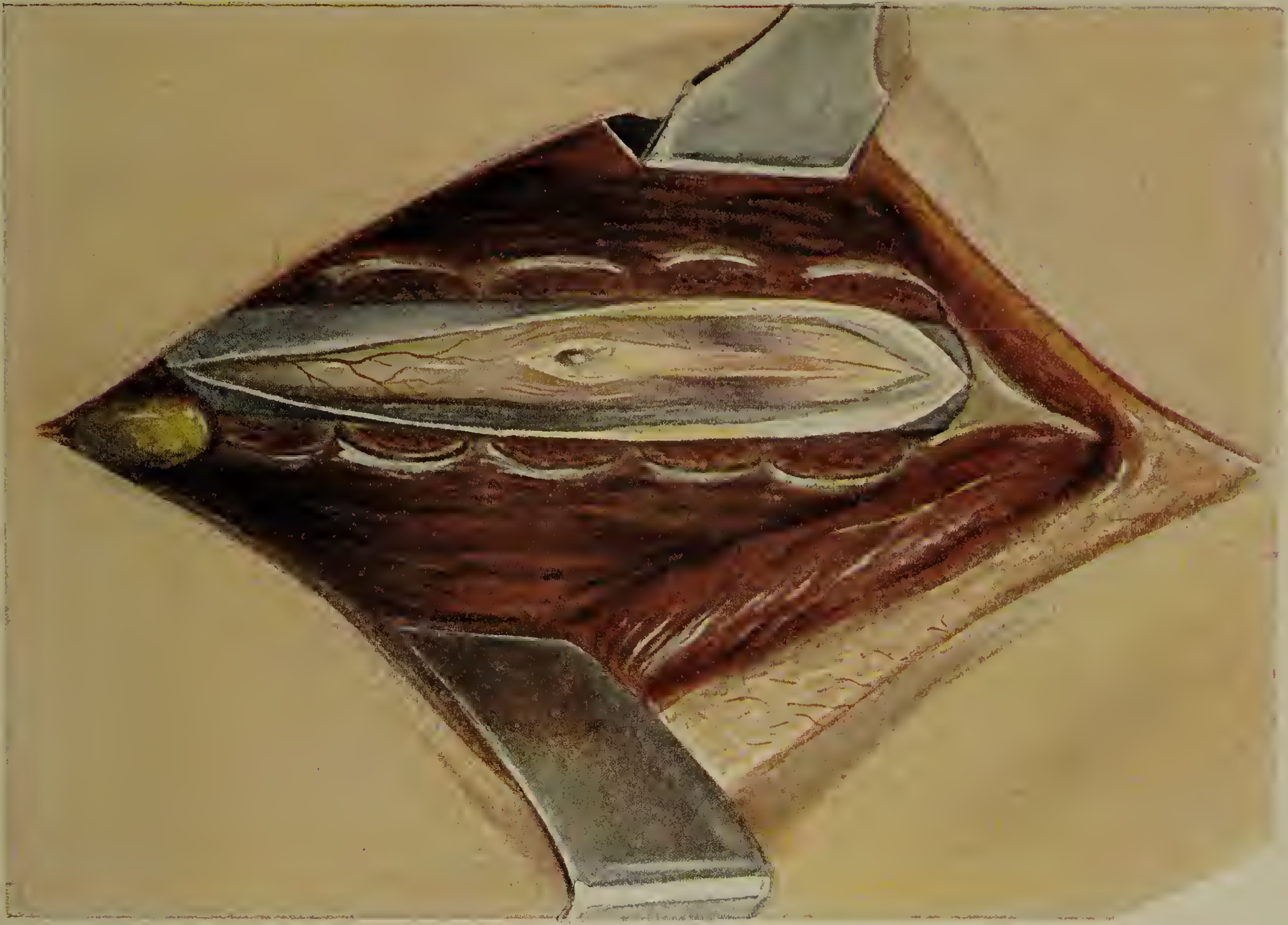


Fig. b.

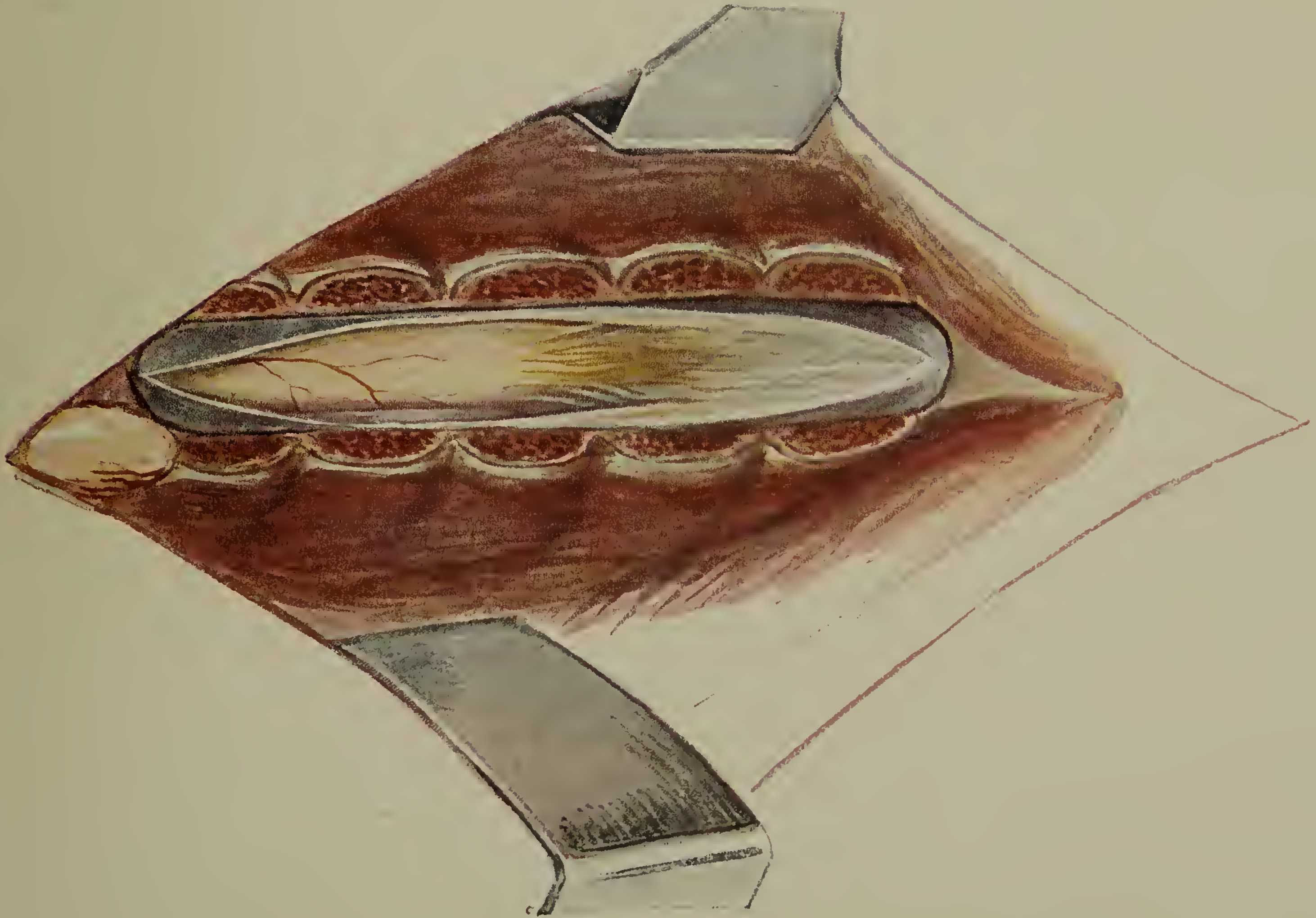


Fig. a.

a chill, high temperature, violent pains and a herpes zoster of the left lower thoracic and upper abdominal region, corresponding exactly to the direction of the ribs, persisting from two to three weeks. In August a similar eruption appeared in the right lower region of the chest, while the abdomen on that side remained unaffected. Soon thereafter, retention of urine developed, which continued for twelve days, and the sensibility in the feet and legs as well as in the anal region was much reduced. This was accompanied with a paralysis of the toes on the right, which developed within a period of eight days. He was subjected to an inunction cure, and about October, 1905, all these manifestations regressed, with the exception of a furry sensation, which persisted in the sole of the right foot.

With reference to the etiology, the patient emphatically denied syphilitic infection. In 1899, however, he suffered from an ulcer on the left forearm, which healed only after the application of bichloride compresses; the scar looked like that of a furuncle. A *Wassermann* test made in 1908 was negative.

In August, 1906, the patient observed a paresis in the extensors of the left foot while walking, and noticed that he became easily fatigued in the entire left lower extremity. The disturbances of sensibility of the sole of the right foot became at that time aggravated. Another inunction cure brought no results. In the course of the year 1907 the motor weakness of the left lower extremity and the disturbances of sensation of the right increased. In December a weakness of the abdominal musculature of the left side was observed, and the sensibility of the right lower extremity up to the gluteal region was decreased. At that time the patient was unable to keep in the erect position without extreme effort, and when attempting to walk, tonic spasms appeared in both lower extremities, which disappeared only after a few steps. The vertebral column from the scapulæ down to the sacrum became sensitive, and the patient occasionally perceived spontaneous pain in these places.

The skin reflexes were exaggerated to such an extent that even the slightest contact with the bedclothes was sufficient to evoke spasms of both lower extremities and the musculature of the lower portion of the trunk.

In January, 1908, a third, very energetic inunction cure was resumed and the iodides were administered. This resulted in a diminution of the marked manifestations of irritation, and the motility and sensibility were changed for the better under fango packings, carbonic acid, and iodide baths.

In the beginning of April, 1908, the patient consulted *Professor v. Wagner-Jauregg* and *Professor Redlich,* of Vienna, who made a diagnosis of probable extramedullary tumor of the left side of the upper thoracic cord and referred the patient to me for operation.

My examinations showed a hyperæsthetic zone for contacts with the brush and needle, which extended posteriorly from the spinous process of the 6th to 9th vertebræ, and in the front from the lower border of the 4th to 7th rib, i.e., on the right side to the anterior and on the left to the posterior axillary line. Hyperæsthesia was more distinct on the right side than on the left. Above this hyperæsthetic band, measuring about four fingers, a number of isolated places of total anæsthesia were found on the right side. From the spinous process of the 9th thoracic vertebra in the back and from the 7th rib in the front down to the gluteal region and inguinal flexure, a reduced sensibility for contacts with the brush and pricks was found on the left side, and on the right total anæsthesia and analgesia were demonstrated in places. There was also a distinct hypæsthesia and hypalgesia on the outer surface of the left thigh and leg; the anal region was also hypæsthetic. There was also complete anæsthesia and analgesia on the outer surface of the thigh on the right side and in the region of the 1st and 2d lumbar segments. In all hypæsthetic regions the sense of localization was also disturbed.

The sense of temperature, beginning from the nipples in front and from the 6th spinous process in the back downward, was much reduced, and on the right side it was entirely extinguished. On the right lower extremity it was considerably disturbed.

With reference to the motility, a marked reduction of power was observed in all movements of the right lower extremity. On the left the ileopsoas was very weak, the flexors of the knee paralyzed, while the quadriceps functionated well. Inward and outward rotation of the thigh were strongly interfered with, and the movements of the ankle-joint as well as dorsal flexion were very slight, so that a pes equinus position developed. The active movements of the left lower extremity (flexion of the hip and knee) were somewhat better. To bring the trunk in the erect position when the patient was lying down, was effected with extreme difficulty without support of the arms. The abdominal musculature on the left side was strongly paretic.

The tonus of the joints was normal in the right lower extremity, while before hypertonia is said to have existed. In the left limb there was abnormal tension in the hip and hypotonia of the knee and ankle joint. The abdominal-wall and cremaster reflexes were absent, and the patellar reflexes were exaggerated to a point of clonus, which was also present in the left Achilles tendon. *Oppenheim* and *Babinski* signs present on both sides.

The patient was able to advance a few steps when strongly supported on the left side, during which he braced himself on the right lower limb so that a scoliotic curvature resulted, especially at the level between the 5th to 8th thoracic vertebræ. The spinous processes of these vertebræ and the arches were sensitive to the touch.

The evacuation of the bladder was disturbed to the extent of compelling the patient to at once satisfy his desire to urinate, lest spontaneous evacuation of the bladder would ensue (*imperative incontinence.—Bruns*).

The main complaint of the patient consisted of a continuous pulling pain in the lower portion of the thorax.

Repeated examinations caused me to suspect the region of the 5th dorsal segment as the point of compression of the cord and I therefore thought best to begin to operate on the arch of the 4th dorsal vertebra.

Laminectomy was performed on the 19th of April, 1908. The arches of the 4th to 8th thoracic vertebræ had to be removed in order to expose the lower end of the morbid condition. At the level of the 4th and 5th arches the dura, which to all external appearances was not changed, was found very tense, like in meningitis serosa chronica, and after incising it a considerable quantity of liquor drained away. The liquor tension was in this instance combined with the actual morbid process, so that the seat of the latter was suspected two arches higher. We have had a similar experience in a case of neoplasm of the spinal membranes.

The principal changes were found in the region of the arches of the 6th to 8th thoracic vertebræ. The dura in this situation was thickened, without pulsation or fluctuation, but not much changed on its posterior surface.

After incising, the arachnoid space appeared empty—not a drop of liquor drained from it. At the upper portion of the exposed region numerous yellowish-red, and in the lower portion pure, cicatricial and fibrous strands stretched between the inner surface of the dura and the spinal cord (see Plate LVIII, Fig. a). In order to afford ample room for the constricted organ, the entire induration was split lengthwise and detached from the cord; below, normal conditions were found to a height of about ½ cm. During the separation of the induration a cystlike cavity was opened at the level of about the arch of the 6th thoracic vertebra; it extended into the posterior section of the spinal substance and contained a clear watery fluid (see Plate LVIII, Fig. b). As much as possible was excised from the induration, and the musculature and skin were finally sutured.

The microscopic examination made by *Professor Oestreich* showed the following findings: Incisions made into various portions of the dura showed similar changes, with the exception that in some places they were more marked than in others. There were foci of small-celled infiltrations, situated around the vessels and consisting of lymphocytes and fibroblasts. The thickening of the walls of all the bloodvessels was striking. In some of them the lumen was situated excentrically, on account of the pathologic changes within the walls. The mural thickenings contained lymphocytes and numerous spindle-shaped nuclei (fibro-cellular tissue), but no calcifications or necrosis or giant-cells. In one place the connective-tissue proliferations projected into the lumen of the vessel (Endarteritis productiva obliterans).

The findings spoke for the assumption of a syphilitic change —a lues duræ matris spinalis. Typical gumma was not found.

The patient withstood the operation well. Three days later the hyperæsthetic zone disappeared, and the girdle sensation also vanished. The condition of the nervous system was at that time the same as before the operation.

On the sixth day after the operation a considerable accumulation of liquor took place in the primarily united wound. Introduction of a probe evacuated it. On the following day the discharge of liquor was greater, and a complete paralysis of the left lower extremity set in, which began to regress very slowly on the thirteenth day after the operation. The flow of liquor persisted for five weeks, but decreased in quantity. Three weeks after the operation another inunction cure was prescribed and iodides administered.

With the cessation of the discharge of liquor severe attacks of spasms of both lower extremities and the musculature of the abdomen and back set in, which extended upward to the region of the shoulders and were accompanied with violent pains. The slightest contact with the extremities, the back, and the abdomen caused a new convulsive seizure. The administration of morphin and chloral caused this condition to disappear.

Despite that, however, a complete motor and almost total sensory paralysis of both lower extremities set in. There was no reaction to the faradic current. This condition lasted for fully nine days, after which the patient was able to voluntarily contract to a limited extent the adductors of his right lower extremity. Three days later it was possible to elicit very slight contractions of the muscles of the calf by faradization, and the movements in the adductors became very distinct.

The motility of the right lower extremity improved in the course of the following days and the patient was able to cause voluntary contractions of the quadriceps. The muscles innervated by the nervus peroneus and nervus tibialis anticus also began to functionate. The function of the muscle groups of the right lower extremity became gradually stronger. The toes also began to move actively, and the foot could be pronated and supinated incompletely and with effort, of course. On the 30th of July the functions of all the muscles supplied by the left nervus peroneus had also considerably improved, and in the right lower extremity most of the movements were executed without restriction.

On the day of the cessation of the flow of liquor the sensibility was almost completely extinguished, i.e., from the nipple downward on both sides. This condition improved on the left side in the course of fourteen days, and after fourteen more days it had also become better on the right side. It began to clear up first in the region of the arm, then on the flexor surfaces of the lower extremities and on the trunk. A strip on the anterior surface of the thigh and the right side of the abdomen remained insensitive. The difference between heat and cold was at that time distinguished correctly.

The lower portion of the rectum was also insensitive, so that the patient was unable to distinguish between hard and soft fæces. This condition improved gradually. The sphincter ani had suffered much in its contractility, so that water introduced into the rectum could not be retained. The muscle tonus returned here also gradually.

From the day following the operation the patient could not evacuate his bladder spontaneously, and he had to be catheterized until he was discharged from the hospital.

On the 13th of September, 1908, he left for his home, and he was at that time able to get about the room with the aid of the walking-stool. The right lower extremity was actively mobile and strong in all joints. The patient could perform all movements of the left lower extremity, but with much less power. The function of the flexors of the thigh was best. The function of the abdominal muscles of the left side was weaker than that of the right.

The tactile sense of the right lower extremity was present on the flexor side alone, and on the abdomen it was extinguished as far as the umbilicus; these regions of the skin were analgesic. The tendon phenomena were exaggerated in both lower extremities and patellar-clonus was absent. *Babinski* and *Oppenheim* positive. Hypertonia of both lower extremities. All contacts with the skin were responded to with violent muscle contractions, mainly in the right lower extremity. The sense of position of the right big toe was normal, in the left uncertain.

A letter from the patient, dated June 27, 1910, informs me that his condition was subject to great fluctuations, which led in the winter of 1908-1909 to an aggravation of the motor functions, which improved, beginning in the Fall of 1909, under the use of injections of bichloride of mercury and the iodides. The general condition of the patient was good, his strength and active movements of the lower extremities were better, so that he was able to attend to his practice as a physician in his residence and also to call on his patients in a carriage at their homes. The only complaint was an occasional intercostal pain.

OBSERVATION XV, 4

Extensive Induration of Tuberculous Nature of the Dura Following Trauma. Resection of the Arches of the Seven Dorsal Vertebræ in Two Sittings. Splitting of the Induration. Aggravation Followed by Improvement.

A farmer, thirty-nine years of age, with negative hereditary history, was admitted to the Augusta Hospital on the 23d of May, 1907. In February of the same year he sustained an injury of the left side of his thorax which led to a secreting fistula. From Easter on, he observed a slight but gradually increasing weakness in both lower extremities, which in the week of Pentecost he felt a number of times while ploughing. Ever since he had that fall he complained of pains in the back and in the shoulders, a gradually increasing girdle sensation and finally marked hyperidrosis. Soon after this he perceived painful spasms in the lower extremities which lasted for a few minutes.

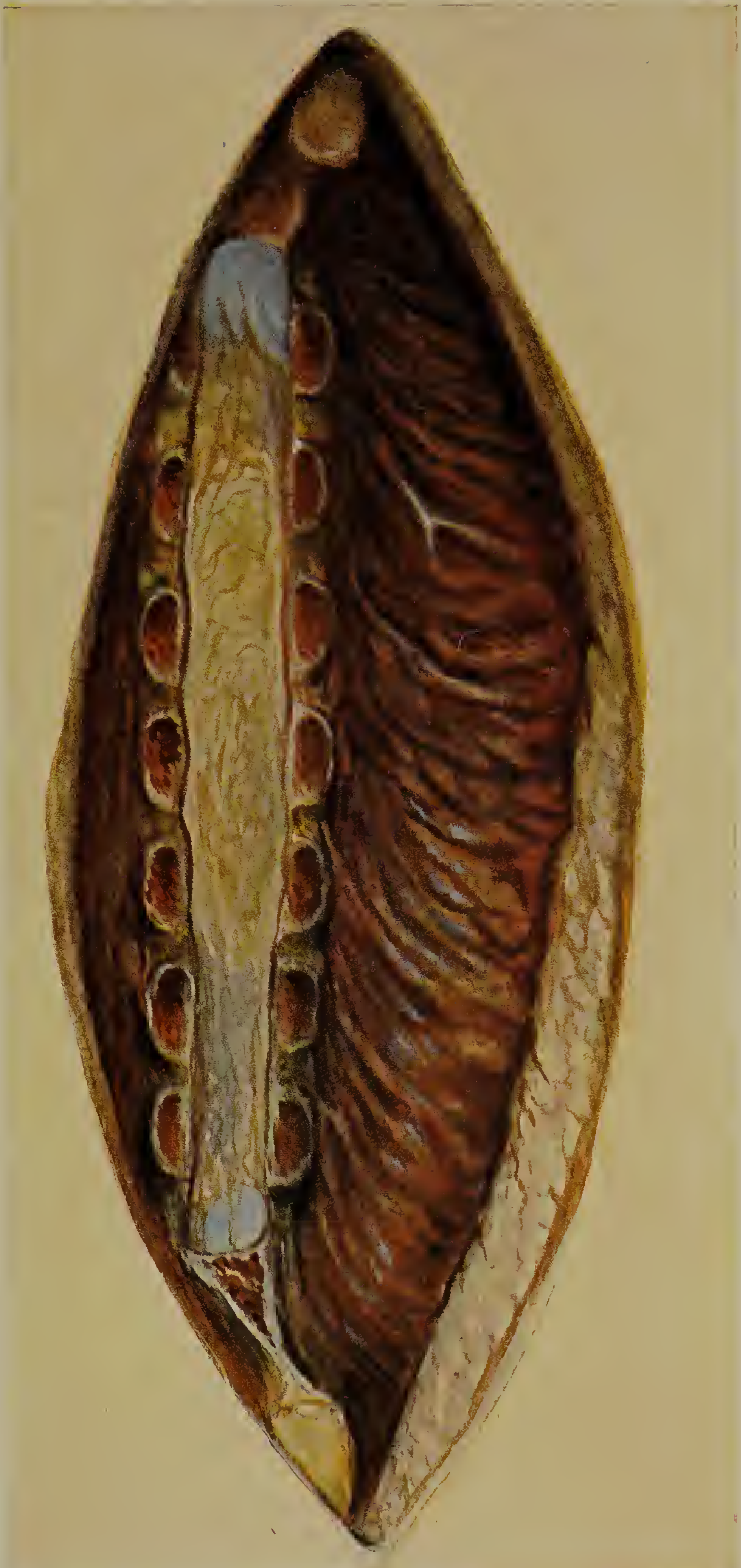
The physical examination showed a pale, powerfully built man, on whose back about 4 cm. to the left of the spinous process of the 10th vertebra, a fistulous opening the size of a pea surrounded by a reddened area, from which a clear watery fluid was occasionally discharging, was found. Percussion and pressure of the vertebræ were not painful, and the vertebral column appeared entirely normal. No changes could be demonstrated in the internal organs. A paresis of both lower extremities was present, which affected all muscles, and which was more marked on the left side than on the right. From the mammillary line down on the left side and on the right from the umbilicus downward the temperature sense was disturbed, and during another examination found entirely extinguished, i.e., on the entire left side and on the right with the exception of the lateral surface of the thigh. The tactile sense had disappeared on the right side from the umbilical line and on the left from the patella downward. The reflexes were exaggerated, especially on the left side. *Oppenheim* and *Babinski* positive. The frequently occurring spasms of the lower extremities were painful and lasted a few minutes.

The manifestations increased in severity during the time the patient was under our observation. He was operated upon on the 4th of June, 1907. The fistula was first probed with a sound as far as the 10th rib, which had to be resected. It was found that the tract did not extend any farther, i.e., it did not reach the vertebral column.

The incision of the skin for laminectomy began at the spinous process of the 5th dorsal vertebra and extended downward for a distance of 13½ cm. The arch of the 8th dorsal vertebra was at first drilled with a burr. After introduction of *Braatz's* sound into the drilled hole, it became apparent that the dura could not be separated from the wall of the vertebral canal. It did not pulsate at the bottom of the wide opening and did not display the normal bluish color, but was of grayish-white appearance, rough and hard. These adhesions rendered the removal of the arches much more difficult. However, this arch, as well as the one above and below it, were removed with the rongeur forceps and the much-changed dura exposed. Neither on the upper nor the lower end of the opening were conditions normal. Since the pulse of the patient became bad, the operation had to be discontinued. The soft tissues were sutured.

On the 15th of June (eleven days later) the operation was completed. Three more arches had to be taken away above and one below, so that in all, the arches of the 4th to 10th vertebræ were sacrificed. The length of the cleft in the vertebral canal was 16 cm. and that of the wound 25 cm. Above and below normal, bluish-looking dura was seen to an extent of ½ to 1 cm.; it was pulsating. In all other portions it was indurated and hard, and pulsations could not be detected even with the finger (compare Plate LIX). Its color was reddish-yellow and spotted in appearance. On the 9th and 10th arches the dura showed a constriction of 3½ cm. in length, and grayish stains in its fundamental color.

In this case the dura was not excised and no portion removed for microscopic examination. It was split lengthwise in



(Scale 3:4)

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its entire extent corresponding to the diseased portion and split to the surface of the cord.

The arachnoid space appeared normal and no liquor cerebrospinalis of any appreciable quantity drained from its upper or lower portion. The incision of the dura was widely gaping—a sign of marked constriction. Judging from the findings of the fistula leading to the 10th rib, there was no doubt that we were dealing with a tuberculous induration. The dura was, therefore, covered with iodoform gauze and the wound sutured over it, permitting the end of the tampon to project from the lower angle of the wound. In the course of five weeks healing progressed under slight serous discharge and without disturbances.

At first the patient was much affected by the two severe operations and his functions became considerably aggravated. After this he recuperated, and on the 3d of October, 1907, he was discharged from the hospital at his request. The vertebral column was freely movable and free from pain. When the patient was sitting up in bed he supported himself with both hands, because he tired easily and fell to the front. In this position he kept his lower limbs mainly flexed, while in the dorsal decubitus they were in spasmodic extension. At passive motions distinct spasms were observed in the lower limbs which were much more marked in the reclining position—almost uncontrollable—and bringing the patient into the sitting posture caused them to decrease somewhat. Touching the thighs made them fly up toward the abdomen like lightning. Active movements of both knee-joints were possible to such an extent that the passively flexed legs could be actively extended slowly and by overcoming the marked spasms. The toes and ankle-joints could also be moved actively to a slight degree, while the feet were in slight pes equinus position. Active movements in the hip-joints were still impossible.

The sense of position and the muscle sense were normal, and all sensory disturbances existing before completely disappeared. The sense of touch, the temperature sense and the sense of pain were entirely normal. The reflexes were normal and not exaggerated. Only the patellar reflexes were somewhat increased. There were no atrophies in any place. Electric irritation resulted in short, lightninglike twitchings of all muscle groups with the exception of both quadricepites femoris, which reacted somewhat sluggishly. No reaction of degeneration. The upper extremities were perfectly free from all disturbances.

On the 2d of November, 1907, the patient informed us that a slight improvement had taken place in the active mobility of the lower extremities. The spasms, however, were said to be still quite marked. Further treatment with massage, baths, electricity and at various medico-mechanic institutes did in no way improve the condition of the lower limbs. A letter, dated August 16, 1909, informed us that the general condition of the patient was excellent and that he was able to supervise his farm, rolling about in a wheel-chair. He supported his back excellently, so that the removal of the seven arches did not interfere with the ability to support the spinal column. He could walk as little as before the operation—the twitchings and spasms prevented him from doing so—although the power of the extremities was increasing.

Intramedullary Neoplasmata

If, perchance, a medullary tumor be discovered, a laminectomy with the removal of arches will at least be beneficial by relieving the pressure (decompression). In most of these cases the neoplasm will have affected the cord sympathetically or infiltrated it diffusely to such an extent that its safe enucleation is out of the question. However, if, as exceptionally happens, the case be one of solitary tubercle or an encapsulated tumor, we should not let it go at that, but interfere. Under such circumstances we are justified in looking for the neoplasm by a carefully executed longitudinal incision corresponding to the posterior commissure, and to attempt its enucleation. As stated before, I have on one occasion incised the posterior commissure of the spinal cord with a scalpel (compare Observation XV, 2, p. 1110) for a length of over 2 cm. and a depth of 2 mm., exposing a focus of softening of at least the size of a pea, in which case the patient recovered.

This teaches that we may entertain hopes to occasionally cure a patient by the extirpation of small, encapsulated intramedullary tumors. Up to this time, however, such cases were invariably looked upon as hopeless. Despite all progress made in neurology, intramedullary tumors cannot clinically be differentiated from intradural neoplasmata (not affecting the cord) with certainty, and we must, therefore, be prepared to occasionally meet the former condition during the operation. A correct diagnosis justifies the attack of an intramedullary neoplasm, as shown by the following observation.

OBSERVATION XVI, 1

Diffuse Glioma of the Spinal Cord. Incision of the Posterior Commissure. Recovery from the Operation, but no Improvement.

A well-developed healthy boy of thirteen began to suffer in September, 1910, from pains in the sacrum and especially in the lower portion of the thoracic part of the vertebral column and of increasing weakness of both lower extremities, especially of the left. For two months prior to this time he was unable to walk unsupported.

The examination of the patient at the time of his admission to the hospital showed nothing abnormal on the cranial nerves, the upper extremities and the upper half of the vertebral column. The spinal column was not sensitive to pressure and showed in its lower thoracic division a slight scoliosis, viz., in the upper portion the convexity was directed to the left, in the lower to the right.

The examination of the motility showed spastic pareses of the lower extremities, especially of the left, which could be lifted to only a very limited extent. Compared with the right, this limb was distinctly atrophic. Of the reflexes, the abdominal-wall response on the left side was indistinct and the cremaster-reflex entirely absent. The patellar-reflexes were highly exaggerated on both sides; ankle-clonus and patellar-clonus on the right side positive. The *Babinski* phenomenon was present on both sides. Examination of the sensibility of both big toes showed on the sides a distinct hyperæsthesia. The right lower extremity and right side of the trunk were hypalgesic for a distance of about two fingers above the navel; its upper border varied. There was also therm-anæsthesia, which extended anteriorly on the trunk to the width of about two fingers above *Poupart's* ligament and posteriorly to the level of the posterior superior spinous process of the ilium.

In accordance with these findings a diagnosis of compression of the spinal cord from the left side—possibly of tumor—was made. Its level was suspected in the region of the 8th to 9th dorsal segments.

On the 5th of January, 1911, I removed the arches of the 7th and 8th vertebræ and the spinous process of the sixth. After the 8th arch was taken away a granulation tissue, like vascular stratum, was found on the dura, which did not pulsate. Longitudinal incision evacuated a moderate quantity of liquor. Intradural probing in an upward and downward direction for a distance of more than the length of a finger met with no obstacles. At the level of the 8th arch the dura did not present a normal appearance but was of a peculiar ivory color and showed a spindle-shaped thickening similar to the cervical or lumbar enlargement.

The ventral leaf of the arachnoid was carefully split lengthwise with a knife and a perpendicularly running vessel of the arachnoid isolated, ligated above and below and excised. After the pia mater was scarified longitudinally, the substance of the spinal cord, especially the neoplasm, bulged in a semispherical form into the entire extent of the incision. Differences in consistency could not be discovered with the finger. A longitudinal incision in the posterior commissure, a few millimetres deep, was made into the substance of the spinal cord with a very fine knife. The spinal cord now bulged into the exposed parts, which measured 5 cm. in length, so strongly from the wound of the dura, that it not only filled the spindle-shaped cleft completely, but projected above it to a greater extent than I have ever seen in cases of normal cords or in extramedullary tumors. It at once became apparent that we were dealing with a diffuse neoplasm which caused a remarkable protrusion of the cord. Since no differences in consistency were observable with the finger or with the point of the knife in any of the exposed parts, we were evidently face to face with a glioma or, perhaps, a myelitis with softening. Microscopic examination of a small particle showed probable glioma. On account of the diffuse extent of the tumor which did not permit the view of normal substance of the cord above or below, the operation had to be discontinued. The incision of the dura remained open and in any event could not be sutured for the reasons given above. Musculature, fasciæ, and skin were sutured without drainage.

The operation was well borne; there was no fever and the healing of the wound was undisturbed. With the exception of moderate flexion and movements of moderate extension of the right foot, both lower extremities were found paralyzed on the evening of the operation. In the course of the following day the mobility of all joints of the right lower extremity returned to a limited extent. The left limb remained immobile and the patient kept the foot in a pointed position (pes equinus). After three days the motility of the right lower limb was tolerably good and on the left side also slight flexion in the knee and ankle joints could be demonstrated; moderately powerful movements of the hip-joint were also executed in this limb. In the following weeks the condition of motility was changeable, and the spastic manifestations became more distinct.

An examination made on the 11th of February showed that both feet were kept in the above mentioned pointed position, and attempts at passive motions were at once responded to by spastic resistance. Movements of the hip-joint and flexion of the knee were possible on the right side with diminished power, and extension in this limb was incomplete. The active movements of the feet were at once interrupted by strong spasms. Active movement of the left hip was possible only to a very limited extent and while flexion of the knee could be executed, it at once culminated in a severe clonus which rapidly affected the musculature of the thigh. The reflexes were exaggerated on both lower extremities, especially on the left side; ankle and patellar clonus were also present on the same side and the *Oppenheim* and *Babinski* phenomena were more marked here than on the right side. All these spastic-paretic symptoms were at times weak and at others more marked.

In the further course of the disease the disturbances of the sensibility showed *Brown-Séquard* symptoms. The sense of pain and temperature-sense were normal on the left side and on the right considerably diminished, while in some places entirely extinguished. After the operation the disturbances of sensibility gradually progressed, at first to the trunk and then to an extent of about the breadth of a hand above the navel. A ribbon-shaped hyperæsthetic zone at the level of the nipples (present at first) could no longer be demonstrated. There was also an œdema of the back and lower extremities which developed in the beginning, but in the course of the trouble it gradually regressed. This was also true with reference to a slight decubitus on the back of the neck. Trophic disturbances of the skin did not exist and the functions of the bladder and rectum were normal. The boy was discharged on the 20th of April, 1911, at which time his general condition was good and no particular changes in the symptomatology had taken place.

Since that time the extirpation of a neoplasm from the substance of the spinal cord was successful. *O. Veraguth*[1] and *Hans Brun* found at the level of the 3d cervical vertebra in a man, thirty-two years of age, immediately underneath the pia mater a solitary tubercle the size of a hazelnut, which was entirely imbedded in the substance of the spinal cord and which was surrounded by a firm, connective-tissue capsule that permitted its easy enucleation.

A case of **angioma of the arachnoid** (ventral leaf) and **pia** observed in a man, thirty-four years of age, in whom laminectomy was performed on the 10th of December, 1910, also belongs to this chapter. The manifestations in this instance were those of an intravertebral neoplasm, and its course extended over a period of seven years. In January, 1906, the patient was treated in the section for internal diseases for manifestations of spinal paralysis. The beginning of the disease had at that time dated back a few years. After the arches of the 9th to 12th thoracic vertebræ were removed and the very tense dura mater opened, a picture (compare Plate LX), strikingly resembling that shown on Plate VIII in Vol. I, of angioma venosum racemosum of the central region, was observed. As in that case, the neoplasm of the spinal cord was also composed of very wide, comparatively thin-walled, bloodvessels of dark-violet color, the course of which was mainly tortuous and interwoven. Since no pulsations could be discovered in this case we were dealing, as in the former instance, with an *angioma venosum racemosum.* Extirpation was out of the question, for the voluminous trunks of the vessels and their ramifications extended into the substance of the cord and I had to be satisfied with deligations alone.

The patient withstood the operation and his wound healed. The paralyses, however, improved in no way and increasing decubitus and consequent exhaustion caused his death three months later. The necropsy (*Professor Dr. Oestreich*) showed in the spinal cord and in the region of the operation, isolated, very turgid veins and immediately above it to an extent of 10 cm. in front and behind (especially posteriorly) indurations, jellylike infiltrations and marked dilations and proliferations of the vessels of the arachnoid. Transverse sections above the field of operation showed the cord to be very small and displaced laterally by the jellylike arachnoid-tissue. Cross section of the field of operation itself showed only remnants of the substance of the spinal cord and a grayish-red structure with numerous vessels. There were also numerous yellowish and gray discolorations, especially in the region of the posterior columns. Tumor-tissue could not be found.

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[1] Subpialer makroskopisch-intramedullärer Solitärtuberkel in der Höhe des 4. and 5. Cervical-segmentes. Operation, Heilung. Korrespondenzblatt für Schweizer Ärzte 1910, No. 33. Basel.

An extensive leptomeningitis fibrosa was found on the frontal brain. The arteries of the base showed no peculiarities.

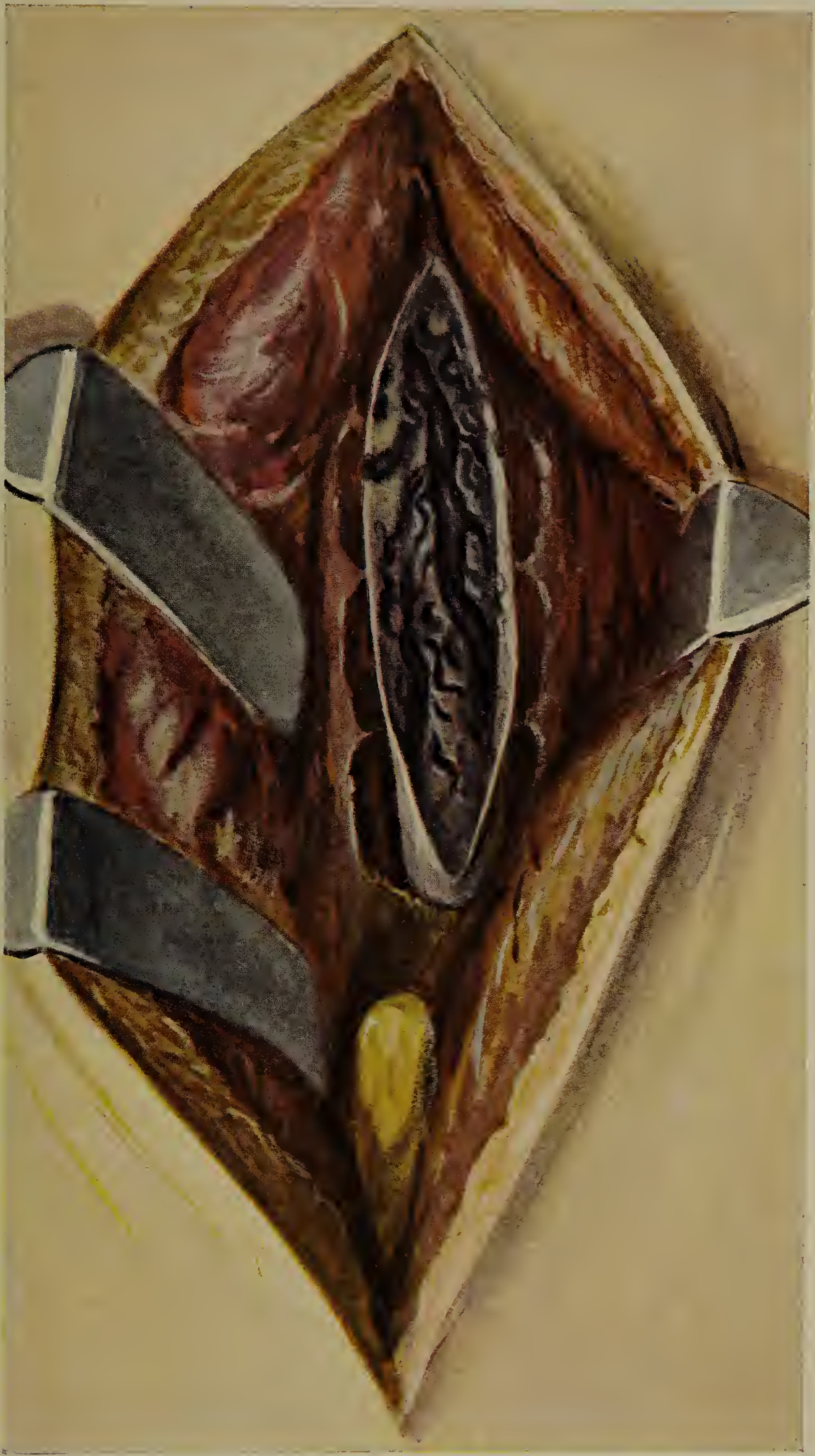
The occurrence of **solitary tubercles** is as rare as **gummata.** These neoplasmata cause the same manifestations as any other space-restricting process within the vertebral canal. Their diagnosis is possible only during the operation. In cases with a positive history of lues an energetic antisyphilitic course of treatment should be tried. Since, however, it is known that old gummatous processes of the bones, skin and tongue are best brought to recovery by surgical means, it is wrong practice to wait, if the process affects the spinal cord, until such time when compression has destroyed the nervous elements beyond hope. In such cases the sooner we decide to operate, the better.

Tuberculous conditions of the spinal cord are very unfavorable, for in most cases they are of a disseminated nature even before the clinical manifestations permit a diagnosis. I once operated on such a case, the description of which follows.

OBSERVATION XVI, 2

Transverse Paralysis of the Thoracic Cord. The Operation Disclosed Solitary Tubercle and Dissemination. Healing of the Wound. Death from Progressive Paralysis.

A man, thirty-two years of age, was suffering from a motor and sensory paralysis in the region of the lower section of the trunk and of the lower extremities which made very rapid progress within a few weeks. There were at first manifestations of sensory irritation, which were later accompanied by motor weakness at first in the left and then in the right lower extremity, and an examination made when the patient was in the depart-



(Scale 1/1)

Rebman Company, New-York.

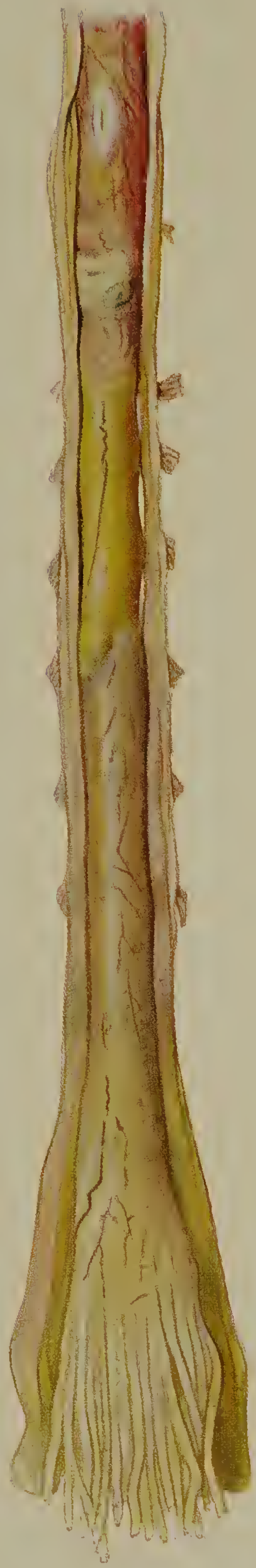
ment of internal diseases (*Geheimrat Ewald*) showed a spastic paralysis of both lower extremities and a disappearance of all sensory qualities which extended to the region of the umbilicus and above this a hyperæsthetic zone. The disease was of a markedly progressive character, so that at the time the patient was admitted to the surgical department, the spastic paralysis had already become totally flaccid and the anæsthesia had reached the xiphoid line. The bladder was paralyzed and the urine showed ammoniacal decomposition and the functions of the rectum were considerably disturbed. Level diagnosis was possible. Since the sensibility above the xiphoid line was normal and, below it, totally extinguished, and because the disturbances of motility were below this line, the diagnosis was that of a complete transverse paralysis at the level of the 5th dorsal segment or the arch of the 4th thoracic vertebra.

After the removal of the 4th and 5th arches the dura was found very tense. Longitudinal incision into it caused the spinal cord to bulge forward and a bloody liquid drained off in moderate quantities. A grayish-red, tumorlike flat swelling was now seen on the pia which was covered with yellow nodules the size of a millet-seed or larger. After the removal of the 6th arch the same changes were found in the entire exposed area. After the removal of these gray-red tumor-masses, the cord appeared slightly excavated and yellow. A blunt tenaculum introduced around the cord to facilitate the inspection of its anterior surface caused a small quantity of liquor of grayish-red color, which was evidently due to softening of the cord, to evacuate. The neoplasm was inextirpable and its upper limit could not be reached, even after the removal of the 4th arch. The macroscopic appearance of tuberculosis was corroborated by the microscopic examination.

The wound healed without disturbances despite the tuberculosis. The patient died, however, sixteen days later from progressive paralysis and pneumonia.

The autopsy (*Professor Dr. Oestreich*) showed the wound entirely cicatrized. The vertebral canal was free from pus. A yellowish-gray, firmly adherent deposit and slight quantities of perfectly clear watery liquid were found extradurally in the field of operation. The arachnoid showed on its anterior side, and especially in its dorsal portion, a yellowish, jellylike infiltration.

The same conditions were found to a greater extent posteriorly. Numerous grayish-white nodules the size of the head of a pin were found in various places of the arachnoid. Above the region of operation greater redness and nodule formations were visible (see Plate LXI). Diagnosis: Arachnitis spinalis tuberculosa.



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Course After Laminectomy

According to our experiences, it is just as difficult to point out the changes peculiar to each region in the course after the operation, as it is to divide with certainty the various space-restricting processes within the vertebral canal before the operation, and for this reason we are unable to enter into their discussion separately.

Disturbances in the Discharge of Liquor Cerebro-Spinalis

In the majority of instances the wound heals without an excessive discharge of cerebro-spinal fluid or too much drainage. I have twice seen so marked an accumulation of liquor underneath the primarily united wound that marked fluctuation was present, and in both cases the abnormal quantities of fluid had to be evacuated by puncture. In other cases again the liquor will dribble away through a suture tract or from a small opening in the wound. The excessive flow of liquor is evidently brought about by the state of irritation of the meninges induced by the operation, which will occur after a severe surgical attack. These manifestations are not only the result of the extirpation of tumors, but traumata, especially after exposure of the spinal cord for old gun-shot wounds, will also give rise to this condition. However, I am unable to give a reason why there will be an excessive accumulation of liquor in one case and not in the other.

Threatening symptoms were only occasionally observed. These will take place when there is a sudden accumulation of liquor under tension and especially when the opening from which it had been previously draining becomes suddenly adherent or closed. The patients will then complain of pressure in the wound, of girdle sensations, pulling pains in the abdomen and in the extremities and spasmodic twitchings of the muscles. In one case of gun-shot wound of the conus medullaris with complete paralysis of the lower half of the body the accumulation of liquor, besides excessive sweating, gave rise to pulling pains in the insensitive lower extremities. A very unpleasant sense of tension will be complained of in the bladder and rectum, which is accompanied by difficulty in urination, which again is accomplished with pain.

The symptoms of irritation may extend from the field of operation toward the peripheral portions of the body or upward. In these severe cases damming back of cerebro-spinal liquor into the cranial cavity may occasion cerebro-meningeal symptoms. The patients will then complain of severe headaches, especially in the forehead and the back of the head, while the movements of the back of the neck remain unrestricted and without pain. They will perspire profusely and have eructations, nausea and vomiting. The general condition of the patient may be much influenced. He may be restless and complain of respiratory embarrassment or be delirious. His tongue will be dry.

The subjective complaints correspond to the striking acceleration of the pulse-rate (120 or even 160 beats per minute), and there are rapid and superficial respirations, pallidity of the face, cyanosis of the mucous membranes, clammy hands and feet and high temperature (in one instance 40° C. per axillam). Sometimes the temperature curve shows a markedly remittent character. I have seen one patient faint and collapse at three different times in the flat, dorsal decubitus.

Patients thus afflicted recuperate from these threatening manifestations in a few days or even a few hours after drainage of the liquor is instituted. If, on the other hand, too great a quantity of liquor be drained away (I have seen not only the heavy dressings but also the bedding and sheets thoroughly saturated), the loss of liquor will again cause headaches, nausea, vomiting, high temperature and even collapse. The diagnosis that these symptoms are due to the loss of liquor, must be based upon its perfectly clear appearance and the absence of all septic manifestations. If the discharge gradually ceases, all unpleasant symptoms will vanish simultaneously.

In weak patients continuous and excessive flow of liquor may even lead to death or, at any rate, contribute much to the fatal issue. Similar disturbances are observed in operations on the brain, but it has been my experience that considerable loss of liquor cerebro-spinalis is more detrimental when coming from the cord than from the brain.

The motility and sensibility of the extremities do not generally suffer as a consequence of the abnormal drainage of liquor. Again, the recuperation of the tracts noticed immediately after the operation may regress, and pareses and anæsthesias may set in anew. In one case the cessation of the flow of liquor caused violent spasms in the entire lower half of the body. These severe symptoms of irritation continued for five days, after which a total paralysis of both lower extremities set in, which gradually regressed without a new flow of liquor. In this case no tumor had been extirpated, but an induration was removed from the membranes of the spinal cord (see Observation XV, 3, p. 1114).

Considerable flow of liquor is a great annoyance to the patient and very trying to the physician and attendants. The patient must be dressed daily, and it is self-evident that frequent change of dressings and the continued saturation of bandages and beddings widely opens the door for infection. However, we were successful in all cases, even where this unpleasant disturbance had continued for a number of weeks, to preserve asepsis. Only one patient died, and she was of extremely weak constitution, and in whom a diphtheritic cystitis and pyelitis developed (proved by the post-mortem examination). The meninges of the spinal cord and brain were in this case normal (see Observation XVIII, 1, p. 1155). All other patients recovered.

Bladder and Rectum, Decubitus

The relief of the spinal cord from the injurious pressure may manifest itself on the day following the operation by the disappearance of the disturbances of the bladder. The urine is evacuated spontaneously and the painful tenesmus ceases. I have observed this favorable return in a few cases of extirpation of neoplasmata from the posterior surface in which the cord had hardly to be touched, and in another case the result was striking. It was an instance of severe induration-formation, in which a focus of softening was found in the cord and evacuated by a longitudinal incision (Observation XV, 2, p. 1110).

Unfortunately, however, even the most painstaking care during the operation will be followed by a paralysis of the detrusor, and the patient will have to be catheterized. The dangers accompanying the constant use of the catheter in patients suffering from paralysis of the spinal cord are well known. We are using *Nélaton's* soft instruments and permit the bladder to be evacuated twice daily. If the paralysis be continued longer than a day, catheterization is followed the first time by an irrigation of the bladder with a 3% solution of boracic acid and the second time by ½ 0/00 or stronger solution of silver nitrate. If the paralysis of the detrusor be accompanied by a paralysis of the sphincters, it is generally looked upon as an unfavorable symptom. I have corroborated this statement a number of times, especially in injuries of the cord from bullet-wounds or from contusions, and have not observed a return of the functions of the lower half of the body in such cases.

Like all other manifestations, the disturbances of the bladder may recur again after they have completely or to a great extent disappeared. They may entirely disappear during the continued regression of the paralysis, or leave only extremely slight traces of their existence behind. I have observed slight disturbances, such as frequent tenesmus, in cases which otherwise were running an excellent course.

In contradistinction to the functions of the bladder, no disturbances of the rectum were observed in any patient after the operation, if interference with the bowel action did not exist before. If the latter be the case, the regression generally requires a longer period than the recurrence of the function of the bladder.

I wish to add in this connection that after successful operation no severe decubitus developed in any case. I have seen, however, superficial bleb-formations on the nates and on all parts of the body exposed to pressure, as for instance the feet. We should, therefore, take care in advance of the Achilles tendons, heels and malleoli and relieve them of every possible pressure, which is best accomplished by permitting the patient to rest on a water cushion, and observe scrupulous cleanliness of the gluteal regions, which should frequently be given alcohol rubs.

Sensory and Motor Disturbances

It is always gratifying to the surgeon to note that after the operation the paralyses recede or at least no anæsthesias or new paralytic manifestations appear. He is then convinced that no added harm was done by his operative manipulations upon the spinal cord.

The hyperæsthetic zone, which, according to our experiences, does not frequently correspond to the upper limit of the neoplasm, may disappear (as all other pains produced by tumors) soon after the extirpation. However, immediately following the operation new pains are complained of, which are not due to the root-regions affected, but are perceived by the patient lower down, for instance, in cases of tumors of the cervical portion of the cord the pain will be in the lower extremities and in the abdomen. These manifestations, which retard convalescence, may in part be due to disturbances in the secretion and resorption of the liquor cerebro-spinalis. These have, however, nothing to do with the pain in the wound. The patients are usually able to distinguish between the two. Wound-pains are generally slight.

Like the pains produced by the neoplasm, the paræsthesias also disappear.

Of the morbid manifestations, the disturbances of sensibility regressed first. Those of the sense of position frequently persisted for a longer time. The anæsthetic regions soon recovered their sensory powers to a greater or less degree. The paralyzed or paretic muscles generally recover slowly, but the paralyses occasioned by the participation of the roots or from compression of the tracts of conduction, will gradually recede if not irreparably damaged by the underlying morbid factor. The roots and tracts of the spinal cord subjected to pressure for the longest time recuperate only slowly and under certain conditions not at all. Those muscles which were first affected during the course of the disease remain farthest behind with reference to recovery.

The improvement in these conditions is not always progressive but is subject to frequent fluctuations. Periods of stand-still and at times frequent relapses are observed. During the examinations the patients become easily exhausted. It may be possible that the interruption in the favorable progress of the disease is caused by the abnormal conditions in the liquor cerebro-spinalis or that this fact is partly responsible for it by retarding the recuperation of the tracts of conduction by the œdema. Equilibrium is finally established and the functions completely restored.

It is of prognostic value when the hypertonia occasioned by the compressing neoplasm disappears but does not give place to complete atonia. In favorable cases the tendon phenomena may be distinctly elicited, even though they lose their exaggeration.

The retention of the reflexes and spasms, even though new pareses develop, is always to be looked upon as a favorable sign. As long as the tendon phenomena are retained, though the spastic pareses have given place to flaccid conditions, experience teaches that hope for the return of function may be entertained.

The pathologic reflexes (*Babinski, Oppenheim, Bechterew-Mendel, Rossolyno*) may soon disappear or become less marked in part or entirely; especially on the side opposite the tumor. In this respect also fluctuations are observed, for they may reappear within a week or two, the spasms may be observed anew and after some time disappear, to return no more.

In two of our cases a peculiar return of the symptom-complexus of *Brown-Séquard* was observed, in the extremity opposite the neoplasm, in such a manner that the previously existing paresis of one lower extremity appeared after the operation in the other limb. The disturbances of sensation behaved similarly but not so distinctly. *Oppenheim* believes this peculiarity to be caused by the pulling upon the spinal cord by the necessary displacement of the lateral tracts on the side opposite the tumor.

Schultze explains the frequent disappearance of the pains in the beginning of the development of tumors by the fact that the growth of the neoplasm destroys the conductivity of the tracts. transferring the sense of pain to the brain. A similar phenomenon has been pointed out by *Oppenheim* in two of our operations (see Observation XIII, 2, p. 1011, and Observation XIII, 3, p. 1025). In these individuals, especially in the first, manifestations of motor ataxia developed during the progress of healing. *Oppenheim* says, in his work cited above: "The ataxia produced by the compression of the posterior columns is at first entirely under cover of the paralysis and is manifest only after the paralytic manifestations have regressed more and more." He also believes that the reappearance of the severe pains in the first weeks after the operation may be at least in part explained on the same basis, for the tracts running cerebralward may, perhaps, recover earlier than the loss of irritability of the deeper tracts and roots compressed by the tumor.

In the case of a man, forty-six years of age, the ataxia was an early manifestation in the course of the disease. The ataxic gait, accompanied by weakness of the lower extremities, was observed by the patient and by his brother, a physician, after the occurrence of a total paralysis of the lower extremities following the performance of lumbar puncture seven weeks before. Since the patient was referred to us in a paralyzed condition, the ataxia could no longer be demonstrated. The operation disclosed a psammosarcoma springing from the arachnoid of the posterior surface of the spinal cord, which, beginning at the level of the arch of the 7th cervical vertebra, extended to the arch of the 2d thoracic vertebra. Barely four weeks after the operation the patient was able when supported by one arm to walk through his room a few times in succession, during which his gait minutely resembled that of a tabetic, which again, according to the description, corresponded to the gait prior to the onset of the paraplegia.

Aggravation of Untoward Manifestations

After every operation upon the spinal cord the existing morbid manifestations may become exaggerated to such an extent that all organs situated peripherally to the field of operation may at first be completely paralyzed. The increase in the paralyses and sensory disturbances naturally depends upon the injuries the cord had been subjected to, even by the most careful operative procedures. The most favorable conditions in this respect are found in neoplasmata that affect the posterior surface. If they be situated more laterally, the cord will naturally be displaced somewhat to the side. If the tumor be situated on the anterior surface of the cord, as in two of my cases, it may be reached only after it has been lifted forward and considerably displaced to the side. No matter how carefully these manipulations be carried out, they will invariably have a certain influence upon the conductivity of the tracts subjected to the manipulation. Fortunately, these neoplasmata are usually located posteriorly or postero-laterally. The following observation offers an example of this class of cases.

OBSERVATION XVII, 1

Psammo-Fibro-Endothelioma of the Arch of the Fourth Dorsal Vertebra Situated Anteriorly and to the Left Side. Difficult Release and Elevation of the Spinal Cord. Cure.

A woman, sixty-seven years of age, relates that in December, 1909, she sustained an injury to the thoracic portion of her vertebral column by being pushed against a bar. Until that time she had enjoyed perfect health and she did not attach much importance to the accident. Her trouble began in June, 1910, with paræsthesias in both lower extremities, which were more marked on the right side and later on developed to a greater degree in this limb than in the left. In the fall of 1910 her extremities became weaker and the paresis of the left lower limb was steadily increasing. In December, 1910, *Sanitatsrät Dr. H. Kron* found spastic pareses of the left lower extremity and a disturbance of sensibility for all qualities on the right side extending upward to the border of the 6th or 7th dorsal segment. The patient was finally barely able to move about with the aid of crutches, and disturbances of the bladder and rectum appeared.

Dr. Kron referred the patient to me for operation. At her admission to the hospital (January 4, 1911) the following conditions were found.

1. *Motility.*—The abdominal musculature was paretic and the patient was unable to sit up from the horizontal position without the aid of her arms. The movements of all joints in the right lower extremity were free, but the coarse power was reduced. A marked spastic paresis was found in the left lower extremity; movements in the hip-joint were only barely present and flexion of the knee and movements of the foot were very incomplete; extension of the knee was better. The extended lower extremity could be lifted from the bed-sheet to an angle of about twenty degrees. When the patient attempted to walk she dragged the

left lower limb, and not the slightest active movements could be performed with it.

2. *Sensibility.*—In the lower portion of the trunk inclusive of the 7th dorsal segment, distinct disturbances were demonstrable, viz., the sense of pain and temperature were markedly affected on both sides; tactile æsthesia, on the other hand, was only barely reduced. Point and blunt could at first not be distinguished by the patient, but on the following days the answers with reference to the left side were correct. The sense of position was somewhat more disturbed on the left side than on the right. The patient furthermore complained of paræsthesias (cold, numbness, occasionally burning) in both lower extremities —more in the right than in the left.

3. *Reflexes.*—The abdominal-wall reflexes were absent on both sides; the knee-phenomenon was lively on the right and more marked on the left. *Babinski* and ankle-clonus were only slightly present on the right side, while on the left spastic symptoms were present, together with the *Oppenheim* and *Babinski* signs and ankle-clonus.

The diagnosis of *Dr. Kron* of a space-restricting process within the vertebral canal was corroborated by our findings. The progressive course of the disease spoke for a probable tumor, the seat of which corresponded to the level of the 7th dorsal segment and which exercised compression mainly on the left side of the spinal cord. Since the symptoms of sensory and motor irritation increased in the following days of the observation, the patient was operated upon on the 12th of January, 1911.

After the removal of the arches of the 5th and 6th thoracic vertebræ and the spinous process of the 4th, the dura did not show any pulsations; palpation imparted the sensation of fluid under tension. After opening the dura, liquor was drained away under moderate pressure. Intradural probing disclosed below perfectly normal conditions, viz., posteriorly and on the right and left sides. However, since an obstruction was met with immediately above the incision into the dura, the arch of the 4th and the spinous process of the 3d vertebræ were taken away. Upon further opening of the dura mater a grayish-violet tumor came to view, which displaced the cord from the left side so that it represented a much thinned, flattened, convex arch curved to the right. The arachnoid was very œdematous and stretched over the tumor. It was scarified longitudinally and the tumor carefully detached from the left side of the spinal cord with a narrow blunt elevator. It was now seen that the tumor had also extended to the front of the cord—in the main anteriorly and on the side. It was carefully divided from the cord with the dissecting forceps and scissors. Three anterior and posterior roots had to be resected in their entire extent from the cord to the intervertebral foramen; this was done because they were entirely surrounded by the tumor-mass. Despite that, however, root-symptoms were fairly absent throughout.

The extremely difficult separation of the tumor from the anterior surface of the cord was accomplished as follows: The pia of the right (sound) half of the cord was seized with a pair of fine-pointed vulsella and in this manner the cord carefully lifted forward. While an assistant steadied the spinal roots on the left side above their point of affection and made them tense with rat-tooth forceps, I divided the fine fibres between the tumor and the cord and was able to completely separate the neoplasm from the cord. The enucleation of the tumor lasted half an hour. The neoplasm adhered to the inner surface of the dura so firmly that it was impossible to remove it completely even with the sharp spoon. The entire dura of the left side was, therefore, excised from the median section to the front, and from the bodies of the vertebræ. Small tumor-remnants adhered everywhere on the inner surface of the dura. After the removal of the tumor the cord presented a convex arch to the right and the narrowing of the organ had already considerably diminished during the operation.

The excised dura was 50 mm. long and 18 mm. in its greatest width. The tumor was 38 mm. long, 15 mm. wide, and 10 mm. in thickness.

The liquor tension was in this instance exclusively below the tumor. Not a drop was evacuated from above. The segmental diagnosis was mistaken by two arches.

The microscopic structure of the tumor (*Professor Dr. Oestreich*) showed it to be a psammous fibro-endothelioma. It was rich in cellular elements and bloodvessels and contained a connective-tissue stroma of partly alveolar and partly netlike structure between which cuboidal and long, flattened cells were present with rounded elongated nuclei. The cells were variously arranged in concentric layers; psammoma bodies were found in the alveoli. Calcareous changes and hyaline degeneration were demonstrable in the walls of the vessels.

The patient withstood the operation very well. Her general condition and strength were excellent and her nutrition very satisfactory. She was able to sit up out of bed as early as on the third day after the operation. On the twelfth day her wound was healed by primary intention, and a slight decubitus ulcer in the sacral region had cleared up. The marked œdematous swelling of the entire lower left extremity existing before the operation soon regressed under treatment with massage, packings, and elevation. For two days after the operation she complained of pains in the back of the neck.

The motility of the right lower extremity showed no changes after the operation; the reflexes, which at first were of a spastic character, were normal at her discharge. The left lower extremity showed a spastic paralysis after the operation, but on the third day slight movements of the toes and flexion of the knee could be executed. After fourteen more days movements of the hip-joint were possible, but with reduced power. Flexion of the knee was possible to an angle of one hundred and thirty degrees and extension was complete. The movements of the ankle-joint, on the other hand, were only barely present. The patient was able to commence walking-exercises on the 15th of February. The marked spasms of the left lower extremity (in the beginning patellar and ankle clonus, *Oppenheim* and *Babinski*, and later on occasionally *Babinski*), gradually improved under massage, walking exercises, electricity, and protracted warm baths. At her discharge from the hospital on the 13th of April they had almost completely disappeared.

The improvement in the sensory conditions was such that the patient complained no longer of any paræsthesias. Generally speaking, at her discharge from the hospital the sensibility was more marked on the right side than on the left, especially for heat and cold, point and blunt, while contacts with the brush were perceived indistinctly on both sides from the umbilical line downward (weaker on the left than on the right side). Thermic irritations were occasionally perceived as pains on the left side (thigh). The sense of position was retained on the right side and on the left it was considerably disturbed. The incontinence of urine considerably improved, the bowel action was sluggish and had to be corrected with laxatives.

Taking it all in all, there was a marked improvement in the general condition of the patient, and she left for her home on the 13th of April. She was at that time able to walk for considerable periods without effort, but with the support of a cane, of course. She writes me that her condition was even better while at home.

In cases where the tumor is located anteriorly or on the side of the spinal cord individual nerve roots are subjected to compression, and, as in the case just cited, must be resected in order to accomplish total extirpation. The operation in itself does frequently produce no greater harm in this respect than is already created by the compression from the tumor. However, even when functionating roots are sacrificed, it does not play an important rôle when they belong to the dorsal segments, but they are of far greater importance in the cervical and lumbar enlargements. The fact that three pairs of roots always innervate a certain sensory or motor region, the division of one or the other need cause no apprehension; but we should not sever all three, unless urgently indicated. Injury to the roots of the phrenic nerve in the 4th cervical segment may place the patient in immediate danger of his life; the pulling upon this segment leads to arrest of respiration, as shown in Observation XIII, 4, p. 1036.

The injuries inflicted during our operations were, as a rule, not of a severe nature, and they disappeared within a few weeks, or, at most, after some months. Generally speaking, the spinal cord bears operative intervention surprisingly well if particular attention is paid to asepsis. Observation XIII, 2, p. 1011, in which the cervical cord was exposed to the lower surface of the atlas and not the least disturbances were observed from this important portion of the spinal cord (phrenicus), may be cited as an example.

The cauda equina may be removed from its bed with less injury than any other portion of the cord. It is here possible to reach or expose the anterior surface of the vertebral canal without inflicting injury to the nerve roots. With reference to this, the reader is referred to Observation XIII, 5, p. 1041.

Return of the Movements

Even in those rare instances in which a complete flaccid paralysis sets in immediately after the operation, there is still a possibility that the conduction of the spinal cord will recuperate at least in part. I recall the case of a neoplasm the width of the little finger which was 35 mm. in length and situated on the right and anterior circumference of the spinal cord, with which it was intimately united. During the operation I had to lift it upward and displace it laterally after removing the arches from the 6th to the 9th vertebræ. It was impossible to detach the neoplasm bluntly, and I had to resort to the knife, with which it was cut away from the cord. In this case the very severe operation was followed immediately after its performance by an almost total interruption of conduction. The patient in this instance was a woman, fifty years of age, in whom, before the operation, only the right lower extremity showed a flaccid paralysis and a certain degree of anæsthesia was present in both lower limbs, and the functions of the bladder and rectum were tolerable. On the evening of the operation flaccid paralysis extended to the navel and only a slight tension was found in the left knee-joint. Both lower limbs were completely anæsthetic and all reflexes had disappeared. The first return of active motility was observed in the left lower extremity in the big and second toes, and in the muscles of the thigh they were noticeable forty-eight hours after the operation. Three days later the left foot was able to execute slight dorsal flexion.

The first reflexes could be elicited twelve days after the operation, viz., at first the *Babinski* phenomenon in both feet. Contacts with the brush were at the same time perceived in isolated places of the right lower extremity, in which pricks with the needle were felt as pains. Fourteen days later the patellar reflex was present on both sides. The movements of the left lower extremity gained in power and extent, and almost every muscle-group could be placed in action, but it was as yet impossible for the patient to lift her leg from the bed-sheet. Active extension of the big toe now appeared for the first time, but it could be executed only two or three times in succession, after which the power was exhausted.

A few days later the patient executed slight movements with the right ankle-joint, and seven weeks later limited flexion of the right hip and distinct extension of the right knee were performed. In three more weeks, the urine, which until that time had to be taken away with a catheter, was spontaneously evacuated a number of times in the day. Later, increased reflex irritability was demonstrable in both lower extremities, while the motility, especially of the left lower extremity, had considerably improved. In the further course of the disease a tolerable function returned to both lower extremities, so that the patient was able to stand up with the aid of two canes, but could not walk. While the totally extinguished sensation of both lower extremities, noted immediately after the operation, had partly returned, the anæsthesia in the abdomen and up to the nipples remained total and improved only slightly in the following months.

I have only rarely observed so rapid an improvement after the removal of an intradural neoplasm as in the following case.

OBSERVATION XVII, 2

Psammosarcoma of the Arachnoid at the Level of the Vertebra Prominens, Extending Down to the Second Thoracic Vertebra. Rapid Return of All Functions After the Extirpation.

A man, forty-six years old, complained of a strong girdle sensation at the lower portion of the thorax, which developed six months after the onset of severe pains in the back, which were mainly perceived between the shoulder-blades and on the right side. Two months later disturbances of walking, with ataxia, set in and disturbances of the bladder function and weakness of the sphincter ani made their appearance. At that time the patient was able to walk about. Lumbar puncture performed at some place resulted in total paralysis of the lower extremities, the bladder and the rectum. Treatment by inunctions improved only the latter functions, while the lower extremities remained almost totally paralyzed; the patient was unable, even when supported on both sides, to walk or even stand. The reflexes were highly exaggerated. The anæsthesia for all qualities about the breadth of two fingers above the nipples and a narrow hyperalgesic zone was present above the 3d rib of the right side. *H. Oppenheim* referred the patient to me for operation with the following diagnosis: "Pressure-exercising process at the level of the 2d and 3d dorsal segments, situated more to the right."

On the 18th of October, 1909, the arches of the 1st to 3d dorsal vertebræ were resected and the lower half of the arch of the last cervical vertebra was taken away. This showed a psammosarcoma springing from the arachnoid and extending from the arch of the vertebra prominens to the arch of the 2d dorsal vertebra and continuing on the posterior surface of the spinal cord. The dura was under high liquor tension *below* the neoplasm and it was transparent, like a hydrocele.

On the evening of the operation the patient was able to evacuate spontaneously a large quantity of urine. On the following day he moved his toes extensively and was able to execute active flexion of both knees. The girdle sensation had disappeared, but recurred fourteen days later in a milder form. Four days after the operation the painful sensation in the lower extremities recurred, and on the following day he was able to move both lower limbs in all joints. Eleven days after the operation the patient perceived thermic qualities, and on the following day he was able to perform his bowel function normally.

He left the bed on the twenty-third day after the operation, and on the following day he stood up alone and could take a few steps when supported by the arm. Two days later he was discharged from the hospital. When he lifted his lower extremities from the bed-sheet the power of the hip-joints was much greater than half normal. Flexion and extension of the knees were accomplished with almost normal power, and this was also true with reference to all movements of the lower extremities. The left lower limb was somewhat weaker than the right. Five days later the patient was able, when supported by the right arm, to walk through the room a few times with greater facility than in the first days after leaving the bed. He could at that time get up from a sitting position on a chair or sofa without supporting himself with the hands or arms. The functions of the bladder and rectum were normal, but his abdomen was still somewhat distended. This troublesome symptom disappeared six weeks after the operation. At that time he was able to walk with certainty with the aid of a cane and he could also ascend stairs. Standing was more difficult than walking on account of the trembling of his limbs. There still existed hypertonia in the ankle and knee joints, and as a consequence a sense of tension. The *Babinski* and *Oppenheim* reflexes, on the other hand, had disappeared on both sides. In the following weeks all functions returned to normal.

Immediately after the lumbar puncture an enormous aggravation in the condition of the patient took place. Since the observations made at that time were furnished by the brother of the patient, a physician, their correctness and veracity were undoubted. While the patient was able to walk about before the lumbar puncture, immediately after its performance he was paralyzed on both lower extremities.

I cannot make the warning emphatic enough against such uncalled-for punctures. Wherever there is sufficient reason to believe that something may be gained by lumbar puncture in a diagnostic or therapeutic sense, it is justified; but what is there to be gained or expected by this operation in cases of intradural neoplasm-formation? The diagnosis of such a condition could at that time be made with certainty without puncturing the patient's spinal canal. It is remarkable that for weeks after his recovery he complained from time to time of pains at the point of puncture.

The dangers of lumbar puncture in cerebral tumors have already been pointed out in Volume I.

Indications, Prognosis, and Duration of the Healing of the Wound

Indications for Laminectomy

When a diagnosis of a space-restricting process within the vertebral canal is made, an operation is unreservedly justified. It makes absolutely no difference whether we are dealing with a solid tumor, an induration, or a circumscribed accumulation of liquor. For, as it has been stated above, the differentiation in most instances is well nigh impossible. We should not permit too long a time to slip by with unnecessary mercury cures and similar therapeutic measures, for the weeks wasted frequently decide the fate of the patient, and a curable paralysis may become incurable during that time. Severe pains are an indication for prompt intervention, provided, however, that the level at which the morbid focus is suspected has been ascertained with some degree of certainty.

As indispensable as exact segmental diagnosis is, we are, nevertheless, frequently compelled to operate without having arrived at a positive level diagnosis. Intradural probing after the removal of one vertebral arch has often shown us the right way. If the patient comes under observation at a stage when the upper limit of the nervous disturbances is not as yet clearly definable, we may wait for a certain time in order to arrive at a reliable level diagnosis. During that time a course of mercurial inunctions and the iodides may be exhibited to advantage.

I do not believe in diagnostic laparotomies, to say the least, of laminectomies and trephinings for the same purpose as advised by a certain prominent surgeon.

If, on the other hand, there exists the slightest probability that the patient may be saved by an operation from what appears to be a hopeless disease, we should not hesitate to interfere.

In these cases, even when the diagnosis is uncertain, we are justified in considering laminectomy, which in itself is not a serious operation.

The differential diagnosis between extramedullary and intramedullary tumor is generally impossible. If the latter be suspected, laminectomy is indicated, because some forms of real spinal tumors are, in my opinion, technically operable, and the removal of the vertebral arches with splitting of the dura mater affords at least more room for the growing tumor, and is, therefore, to be looked upon as a palliative operation (decompression) of value.

Prognosis

Experiences in this respect gathered from one clinic, whose cases and number of operations are many, are most conclusive. I am, therefore, giving my own statistics to the end of July, 1911. From these the laminectomies for various injuries and for tuberculous spondylitis are left out, and of neoplasmata of the vertebral column only five that came for operation with a wrong diagnosis of intravertebral tumor are considered.

I have opened the vertebral canal for tumor or conditions giving a similar symptomatology (meningitis serosa chronica, indurations) 45 times in all. These 45 operations were performed on 44 patients (in one case the operation was necessary at two different times).

Twenty cases were operated upon for neoplasmata of the dura mater or the soft coverings which grew toward the cord; 11 fibrosarcomata, one with myxomatous changes; 1 fibroma, 1 psammoma, 1 lipoma, 1 angioma, 3 angiosarcomata, 2 psammosarcomata, and 1 extensive malignant endothelioma. In one case a non-removable intramedullary neoplasm was encountered.

Of the 5 cases of neoplasm springing from the vertebral bodies, 2 were enchondromata and 1 exostosis, which could be removed with the chisel; 2 were sarcomata, 1 myelogenous sarcoma, and 1 periosteal soft, round-cell sarcoma—both inoperable. In these two operations decompression by laminectomy was done and as much tumor-tissue removed as possible.

Solitary tubercle was found and extirpated twice. Three operations were performed for tuberculous indurations and one for syphilis. In a fifth case the histologic examination failed to disclose specific tissue metamorphoses.

The remarkable manifestations of chronic serous spinal meningitis were found eleven times and the acute once.

I have operated on the cervical portion of the spinal cord ten times and have opened the dura nine times. In two of these cases I had to remove the arch of the epistropheus, and in these two cases, which were the most serious of the whole series, recovery ensued. In view of my experiences, I would not hesitate to resect the posterior arch of the atlas and expose the medulla oblongata by removing the bone surrounding the foramen occipitale magnum.

I mention this emphatically, because ***Fr. Schultze***[1] has correctly diagnosed a compressing neoplasm at the level of the atlas in the case of a laborer, thirty-six years of age, whom he failed to refer to the surgeon for operation on account of the "dangerous territory in which the tumor was located." The patient died, and the post-mortem examination disclosed an entirely remediable state of affairs—an extradural encapsulated and enucleable tumor the size of a walnut which shut off the right half of the foramen magnum and on the left formed a cleft for the passage of the medulla. Since the tumor was a fibroma or fibrosarcoma, the patient could have been saved.

Twenty-seven operations were performed on the thoracic portion of the cord and the dura was split twenty-four times. The lumbar portion was attacked eight times, and the dura mater opened six times.

Nine of my patients died immediately after the operation, viz., four in collapse (three of these did not lose much blood). Two of these operations were performed on the cervical cord, one in the thoracic and one in the lumbar portion. In all four cases the dura mater was split lengthwise, corresponding to the entire extent of the wound. Death also resulted once from pyelitis in eight days, and from pyelitis and broncho-pneumonia after five days, and in one case from an unknown cause and with a healed wound eleven days after the operation (post mortem not permitted); once from double pneumonia ten days after the operation; and only once from purulent meningitis. In this last patient there was decubitus, with paralysis of the bladder and ichor. In order to remove the tumor, I had to remove the arches of six thoracic vertebræ (5th to 10th). While the course was entirely normal in the first five days after the operation, on the evening of the sixth day a chill, followed by fever, set in. The infection was therefore secondary to the decubitus, the putrid urine and the continually saturated dressings.

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[1] Zur Diagnostik und operativen Behandlung der Rückenmarkshautgeschwülste. "Mitteil. a. d. Grenzgeb. d. Med. u. Chir.," 1903, Bd. XII, p. 157 f.

Of the last twelve cases operated upon for intradural neoplasm, only one patient died from pyelo-nephritis and exhaustion. All others were discharged from the hospital after complete healing of the wound. My results have of late considerably improved on account of the greater experience and improved technic.

The condition of the spinal cord at the point of compression is naturally of the greatest possible importance for the prognosis. Even where damaging influences of pressure are exercising their deleterious effects upon the cord for a long time, its ability to recuperate will frequently surpass our expectations. I have observed, for instance, two cases in men, one twenty-four and the other twenty-eight years of age, who, as a result of intradural neoplasmata in the cervical cord, were almost completely paralyzed in all four extremities, and in whom after a few months a return of almost all functions took place. Even during the operation we could see the deep trough in the spinal cord become flattened.

The cord seems to be especially resistent to gradually increasing pressure such as is exercised by neoplasmata. Sudden compression, on the other hand, such as results from a bullet-wound or other penetrating injury, is capable of producing a permanent interruption of conduction, even though operative exposure does not disclose marked changes on the visible surface of the cord.

Of course, where excessive compression is exercised by the tumor upon the cord for too long a time, successful extirpation will not always restore its conductivity.

We may mention in this connection the case of a merchant, twenty-nine years of age, in whom an encapsulated sarcoma of the extraordinary extent of 90 mm. was removed in two stages on account of collapse of the patient on the operating table, leaving an interval of ten days between the two procedures and sacrificing the arches from the 1st to the 5th thoracic vertebræ. The violet, firm neoplasm (fibrosarcoma) occupied the entire exposed surface of the spinal cord to a width of 20 mm., and had to be split in the middle in order to extirpate it from the much-compressed cord without inflicting great injury to its substance. The thickness of the tumor at the point of its incision was over 1 cm.

The trouble began two years before the operation, with extremely violent neuralgic pains in the shoulders. Six months later the right lower extremity, and six weeks thereafter the left lower limb, became paralyzed. Severe disturbances of the bladder and the rectum occurred simultaneously and extensive decubitus ulcers added to the misery of the patient, and sixteen months before the operation a total interruption of conduction set in, which extended to the level of the 5th rib. Since the tendon and skin reflexes were highly exaggerated during the entire time of observation and the paralyses after the operation were of a decided spastic nature, I entertained hopes for the recuperation of the tracts within the spinal cord. However, we were much disappointed in that not a single function was restored nine weeks after the operation or at the time when the patient was discharged from the hospital.

The

Duration of the Healing of the Wound

has already been spoken of above.

The final cure of the paralyses usually takes a number of months. However, it may last a year or more, until the functions of those portions of the cord and nerve-roots return as much as the anatomic changes will permit. I have seen a decided improvement in the remaining paralyses two years after the operation.

I have never seen a recurrence, even in sarcoma of the arachnoid.

Concerning neoplasmata of the membranes of the spinal cord, we are justified in speaking of a cure in those cases in which the remaining disturbances will at least permit the patient to walk about even with the support of canes. I can recall twenty such cures in thirty-five patients successfully operated upon by myself. Fourteen of these were complete cures, i.e., either no remnants whatever of the paralyses could be demonstrated, or they were so slight that they could practically be considered nil.

A man, twenty-four years of age, who was paralyzed in all extremities, was able, a year after the operation, to ascend the Hermann Monument at the celebration of the War of the Teutoburg, and is at present studying medicine. Another patient, who was also in an apparently hopeless condition, is now a director of a chemical laboratory and is able to walk ten miles at a stretch. Both of these patients were afflicted with tumor of the cervical cord.

In the dorsal portion of the cord I have had six excellent results, one in its lumbar portion and one in the cauda equina. With reference to the dorsal cord, I have observed the regression of the paralyses in a woman, thirty years of age, twenty-four days after the operation, so that she was able to walk about. We have also seen a man, forty-three years old, who was suffering from a psammosarcoma of the arachnoid at the level of the arch of the 7th cervical vertebra and extending to the 3d thoracic vertebra, to leave his bed twenty days after the extirpation and to walk about in three more days when supported on the arm by a nurse. In the case of a woman, sixty-seven years of age, the extirpation of a tumor on the anterior surface of the cord, complete cure was obtained, with the exception of slight residual symptoms.

In three of my other cases the paralyses improved only slightly or not at all; so that the patients were discharged unimproved. In one of these cases the tumor was situated on the anterior surface of the dorsal portion of the spinal cord, and in the other instance it was posterior and laterally, and a complete paralysis of the lower half of the body persisted for almost two years. In the third case I was unable to completely extirpate the very extensive sarcoma in the region of the lumbar portion of the cord and the cauda equina, evidently because it was not encapsulated.

Neoplasmata and Tuberculosis of the Vertebral Column

In neoplasmata springing from the bone, the medulla, and the periosteum of the vertebral column, we distinguish two clinically entirely different groups. One of these (the more important) comprises those neoplasmata which principally or exclusively project into the vertebral canal, narrowing it and occasioning thereby all manifestations produced by neoplasmata of the spinal cord and its membranes. Their anatomic composition may be benign, and if so, are represented by **osteomata, enchondromata or fibromata.** For enchondromata I am citing the following observation.

OBSERVATION XVIII, 1

Intravertebral Enchondroma of the Body of the Sixth Cervical Vertebra. Eight Days After the Operation, Death from Exhaustion. Diphtheritic Cystitis and Pyelitis.

A woman, twenty-two years of age, observed five years prior to her admission to the hospital, weakness and paræsthesias in the lower extremities which first began on the left side. When sitting, she perceived pains in the back and was therefore obliged to remain in the reclining position. After a few months a weakness in urination was noted and she perceived pains in the hypochondrium when attempting to assume the erect posture. For about a year and a half weakness and twitchings in the left arm and paræsthesias in the little finger were noted. She observed that the left hand always felt hot and the right cold. In the summer of 1907, evening rises of temperature to 39° C. and morning rises to 37° C. persisted for about a month and a half. Before the trouble began striking changes were observed in the finger-nails at first of the right hand and later on in the left. The mother of the patient also showed these *ungual* changes. They consisted of conditions as found in onychogryphosis, more marked on the right side. Besides these there were likewise so-called " Drummers' fingers."

In October, 1907, she was examined by *H. Oppenheim.* Considerable weakness was observed in both lower extremities, especially in the left. The latter could be lifted from the sheet with slight power for a distance of about a foot. Flexion and extension in the knee-joint were fairly powerful and the extension in the ankle-joint was incomplete, while flexion was somewhat more powerful. There was also continuous varo-equinus position of the same limb. The movements of the right lower extremity were much better. There was considerable rigidity in both lower extremities, with decided ankle and toe clonus of the left side. *Babinski, Oppenheim,* and *Bechterew-Mendel* were distinct on both sides.

The power of both upper extremities, especially that of the right arm, was practically normal, while the hand-shake of the left side was very weak, and there was also an atrophic paresis of the interossei and an inability to adduct the 3d and 4th fingers. The tendon phenomena of the upper extremities were also exaggerated to a pathologic degree, especially in the left.

Tactile anæsthesia was found in many places of the right lower extremity, but nowhere on the left side; the temperature sense was also reduced in the right lower limb. Pricks with the needle were perceived in the right leg and foot as painful. The sensation was less marked here than on the left side, in which limb, especially in the foot, the sense of pain was above normal. Disturbances in the sense of position were present in both lower extremities, and in the left big toe it was entirely absent. Tactile anæsthesia of the trunk extended upward to the lower border of the 2d rib, and was the same on the right side also. It continued to the median side of the left arm. The zone of analgesia corresponded to that of anæsthesia.

The abdominal reflexes were present on both sides. The left pupil and the palpebral fissure were narrower than the right.

When the patient attempted to sit up or lie down, she perceived pain in the upper dorsal region between the shoulder-blades. The spinous process of the vertebra prominens was ex-

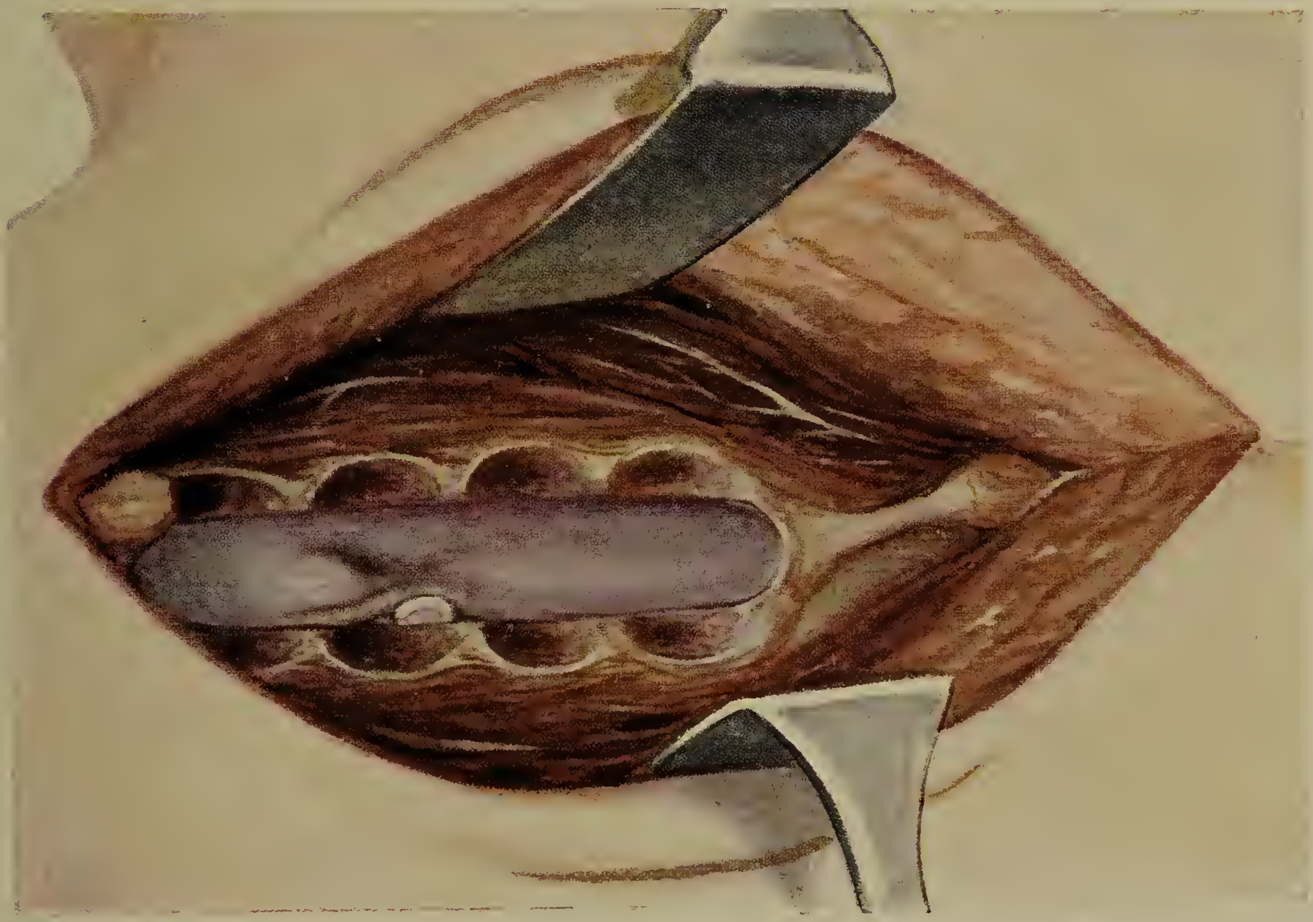

Fig. a.

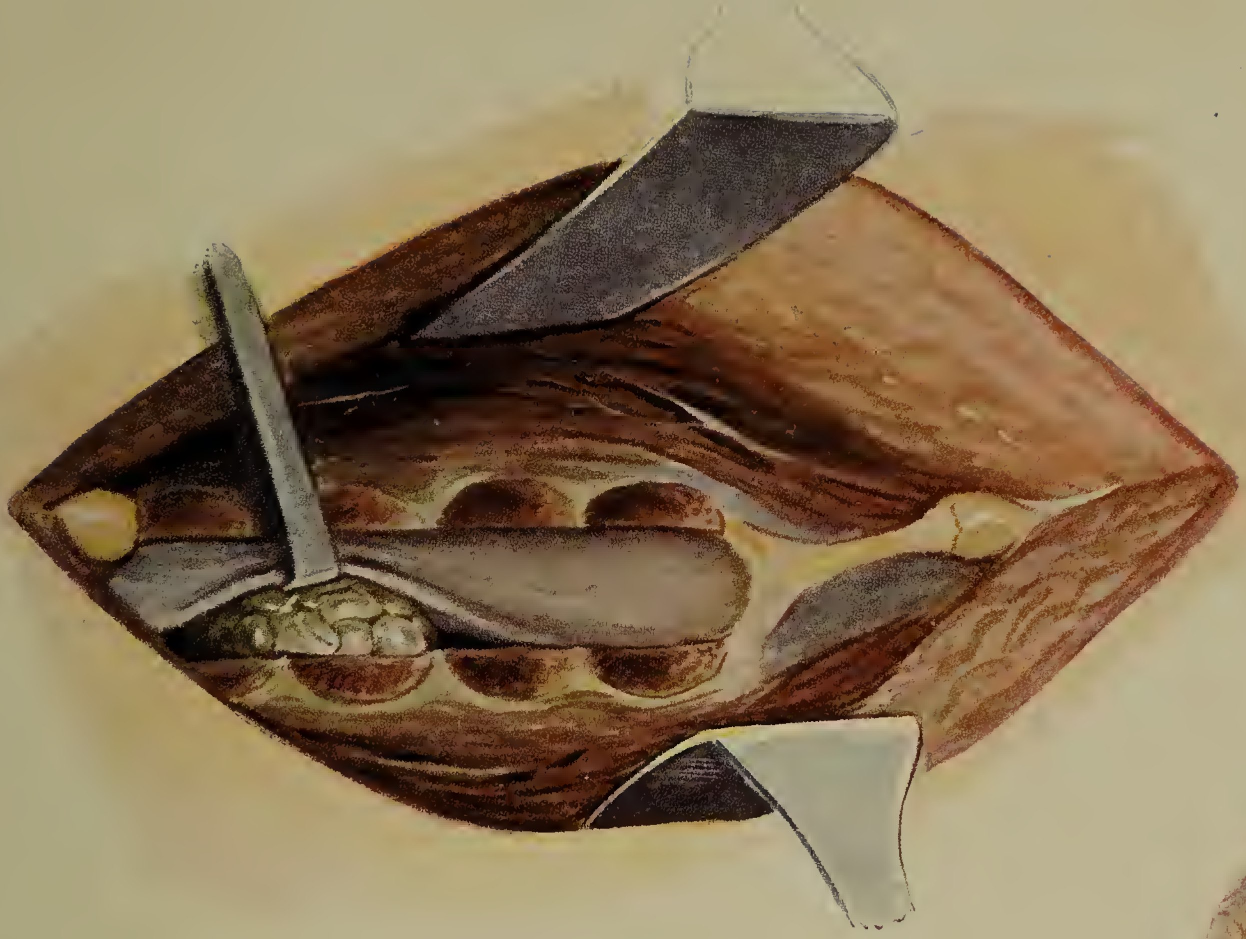

Fig. b.

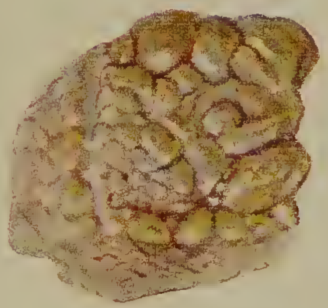

Fig. c. (Maßstab $^{1}/_{1}$)

Rebman Company, New-York.

tremely sensitive, and the process of the 3d thoracic vertebra was the same.

The patient was referred to me by *H. Oppenheim*, with the following report:

"The patient presents symptoms which cause us to think of a neoplasm in the region of the upper dorsal or lower cervical cord, especially on the left side. Many factors, especially the gradual onset of the process in an upward direction, speak for an intramedullary seat of the trouble. Trophic disturbances of the finger-nails strengthen this view (gliosis). The decided sensitiveness to pressure of the vertebral column, especially that of the 3d and 4th dorsal vertebræ, is remarkable. *Dr. Immelmann* believes he has found a change in the bone on the X-ray plate. I am sceptical in this view." During the operation *Dr. Immelmann* was found to be correct. "I suspect the morbid condition to be about the level of the 7th cervical vertebra. It is possible that, outside of the extramedullary neoplasm, an accumulation of liquor is present above it at the level of the 3d dorsal vertebra, which gives rise to the symptoms observed in the left arm. In view of the hopelessness of the condition, I would advise operative intervention, not laminectomy, but puncture of the subarachnoid space through the arch of the 1st thoracic vertebra, which would relieve the tension consequent to the accumulation of liquor, if such be present, and thus enhance the making of a correct diagnosis."

After further consultation we decided on laminectomy at the level of the 7th cervical to the 3d thoracic vertebra. After removal of the 2d arch the dura appeared bluish-red in color, very tense, and it did not pulsate. After further exposure the arches of the 1st thoracic to the 7th cervical vertebræ were removed. At the level of the 7th cervical vertebra a bluish-white, glistening, cartilaginous structure the size of a pea was found on the left side of the dura near the vertebral canal, which displaced the dural sac to the right and anteriorly, and extended farther above (see Plate LXII, Fig. a). For this reason the arch of the 6th cervical vertebra was removed, which exposed the upper end of the tumor. Above it distinct pulsations of the dura were visible. The neoplasm was visible only from the left side and its greatest portion was hidden from view by the sac of dura overlying it. It extended from the 7th to the upper border of the 6th cervical vertebra. It was an extradural tumor—an enchondroma springing from the body of the vertebra. The left side and anterior surface of the sac of the dura were blended with the surface of the tumor, and it was separated with the raspatory as bluntly as possible, without subjecting the cord to pressure (see Plate LXII, Fig. b). During this procedure the 7th cervical roots came to view.

In order to save the cord from injury the base of the tumor, corresponding to the body of the 6th cervical vertebra, was divided by a few smart blows with the mallet, and the tumor bluntly luxated in such a manner that the surface of the hammer brought it to view from the vertebral canal from left to right, and care was taken that it should come in contact with the surface of the dura as little as possible. Despite the greatest of care, the dura tore at the level of the 7th cervical vertebra on the left side to a length of 2 cm. and a considerable quantity of liquor was evacuated. After the removal of the tumor the exposed dura pulsated visibly. The spinal cord was compressed to a flat ribbon at the site of the tumor. The remnants of the neoplasm within the body of the 6th cervical vertebra were taken away with a sculptor's chisel. The tumor was the size of a walnut (see Plate LXII, Fig. c). The cavity in the bone corresponded to the size of the 6th cervical vertebra.

The tumor consisted of transparent, cartilaginous tissue, and had a nodular, glistening surface.

The much-affected patient, who suffered for a long time from a severe cystitis, became weaker after the operation as a result of the marked discharge of liquor. She died eight days later from exhaustion. The post-mortem examination (*Professor Dr. Oestreich*) showed the wound of the operation to be in good condition. In the region of the operation a slight extramedullary hemorrhage was found, which infiltrated the arachnoid in an upward and downward direction. No meningitis. A slight remnant of the enchondroma was found in the vertebral canal in the form of a white mass, which extended through the intervertebral foramen to the front. The white tumor-mass had the form of a flat disc, the size of a dime. In the region of the tumor the spinal cord was thinned to 2½ cm. and soft. The area of softening lay immediately below the cervical enlargement.

The bladder was filled with an ichorous, purulent fluid; it had a red, hemorrhagic appearance, and was in part diphtheritic. In the pelvis of the right kidney hemorrhagic hyperæmia existed. Both kidneys were cloudy and yellowish. The spleen was small, soft, and its cut surface was moist. The heart was brittle, very cloudy, and its valves were intact.

The second form, **the malignant tumors,** affect the vertebral column either primarily and will then show the histologic picture of a periosteal or myelogenous sarcoma, or they are secondary metastatic neoplasmata, which are mainly of carcinomatous nature. The carcinoma projects, as a rule, from without inward toward the spinal cord. Metastases in the substance of the cord itself are very rare, yet such cases have been reported. *J. Orth,*[1] for instance, describes the case of a man, fifty-eight years of age, who was suffering from a primary carcinoma of the lungs and bronchi, in whom, outside of numerous metastases in the left frontal and temporal lobes of the brain, a carcinomatous nodule of the *lumbar portion of the spinal cord* was found. "At the end of the lumbar enlargement, about ½ cm. above the filum, a marked nodular thickening is apparent, which runs downward to a point. The consistency of this swelling is firm. Transverse section of the spinal cord in this region discloses only the left third of the white substance, while the middle and the right third (the latter almost totally) are infiltrated by a knotty tumor of grayish-red color."

The diagnosis that the tumor does not originate from the spinal cord or its membranes, but from the vertebral column, can only be made when the X-ray picture offers conclusive evidence to that effect or when the focal manifestations of the vertebral column point invariably in that direction. In the latter respect, deformities from without or palpable swellings in the pelvis or through the abdomen, local sensitiveness to pressure, spontaneous pain in certain sections of the vertebral column, rigidity in the movements and pain during their execution, were the leading symptoms. However, all these signs frequently lead us astray and we decide to operate, and when confronted with the real nature of the trouble, we are convinced that to have abstained from the operation would have been the better course.

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[1] Bericht über das Leichenhaus des Charité-Krankenhauses für das Jahr 1909. Charité-Annalen XXXIV. Jahrg. Sekt., No. 1258.

If an elderly patient be the sufferer from a primary carcinoma, or if he undergoes an operation for his tumor, the manifestations, appearing later in the form of a pressure-paralysis of the spinal cord, will at once cause us to think of a metastasis. Metastatic carcinoma of the vertebral column is not at all uncommon in women who have suffered from, or, perhaps, have undergone an operation for cancer of the breast.

In instances where a diagnosis of tumor of the vertebral column (of the second group) has been made, which restricts the space of the vertebral canal at a later stage, an operation is generally contraindicated, for in most of these instances we are dealing with sarcomata which cannot be removed to the desired extent. If the manifestations referable to the spinal cord are severe, especially in violent pains, laminectomy is to be taken into consideration. It is to be performed, of course, when the strength of the patient is in tolerable condition. Its function is to release the spinal cord and the posterior nerve roots from the injurious pressure occasioned by the intravertebral tumor similar to cases of tuberculous spondylitis. Resection of the sensory roots should be practised in severe neuralgias. The spinal cord will then be able to expand in the direction away from the tumor in the cleft created and, since during the performance of this operation the dural sac need not be opened, the procedure is not particularly dangerous.

This palliative measure has given me satisfactory results in a few cases, and deferred for a period of eleven months the death of a girl eighteen years of age who was suffering from general sarcomatosis. Resection of the arches of the 2d and 3d thoracic vertebræ in a man fifty years of age brought to view a dark brown-red, lobular mass, which compressed the dura from the left side and continued upward to the nearest arch. The removal of the latter showed the neoplasm also on the right side of the spinal cord. It had surrounded the dural sac. While the sarcoma was intimately united with the dura, its removal from it was possible. In this case also improvement was noted in the way of cessation of the pains.

Despite all progress made in diagnosis, we must confess that in a great many cases it is, unfortunately, impossible to decide whether the tumor originated in the membranes of the spinal cord or from the bones of the vertebral column. When a deformity of the spinal column or unusual pain points to its affection, tumor of the vertebral column may be suspected. In most cases, however, where the tumor originates from the inner surface of the arches or from the posterior side of the bodies of the vertebræ, their recognition remains uncertain even in those cases where the neoplasm has grown through the body of the vertebræ and the destruction is extensive. Even in these cases the spinal column may remain freely movable and free from pain.

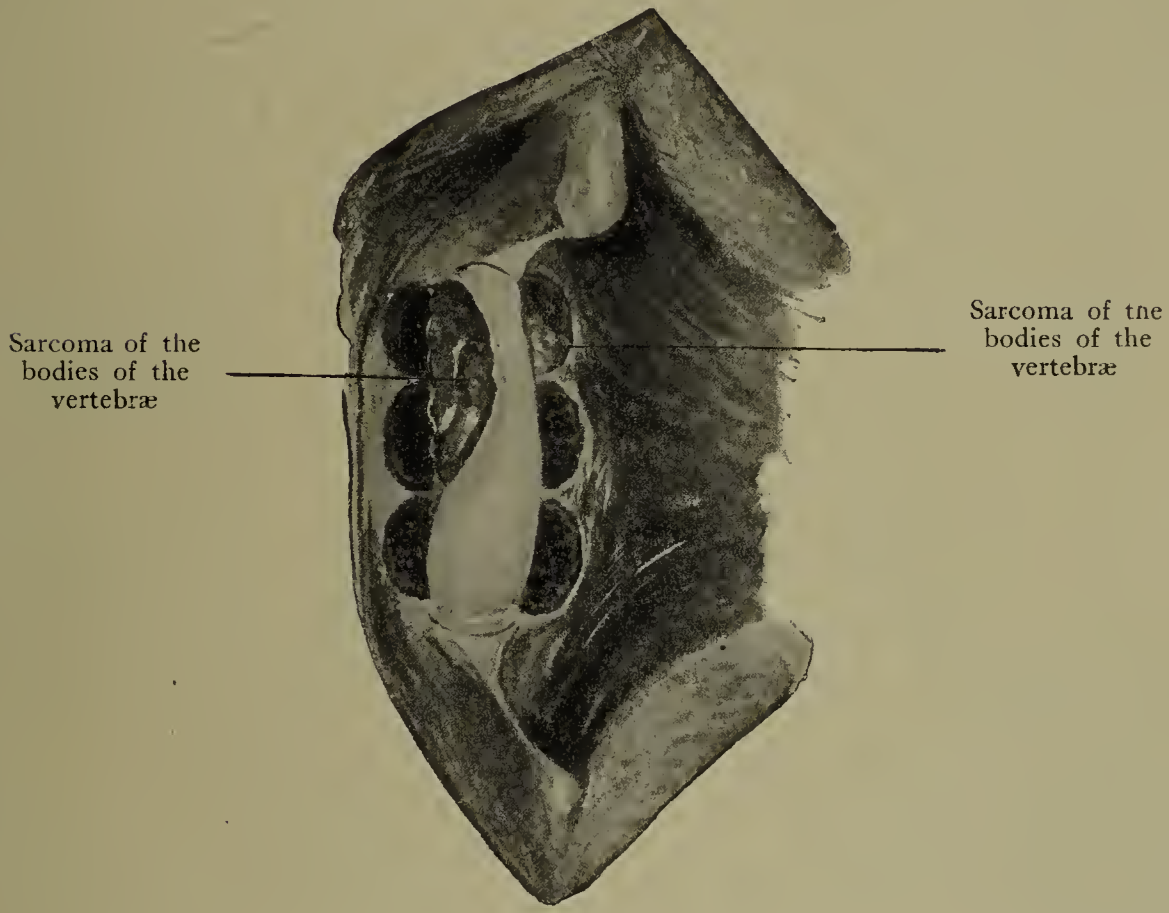

Sarcoma of the bodies of the vertebræ
Sarcoma of the bodies of the vertebræ

Fig. 180

The surest diagnostic method is the X-ray picture, when it offers conclusive evidence. Fig. 181, on page 1162, shows a sarcoma of the bodies of the 3d and 4th cervical vertebræ in the case of a man, forty-three years of age. Unfortunately, this method frequently disappoints us.

H. Oppenheim attaches much importance to percussion. A decided dulness or lower pitch of the percussion sound may be caused in some doubtful cases by a neoplasm not too distant from the surface, while in intradural neoplasmata the value of the percussion note is very slight or cannot be utilized as a diagnostic phenomenon at all.

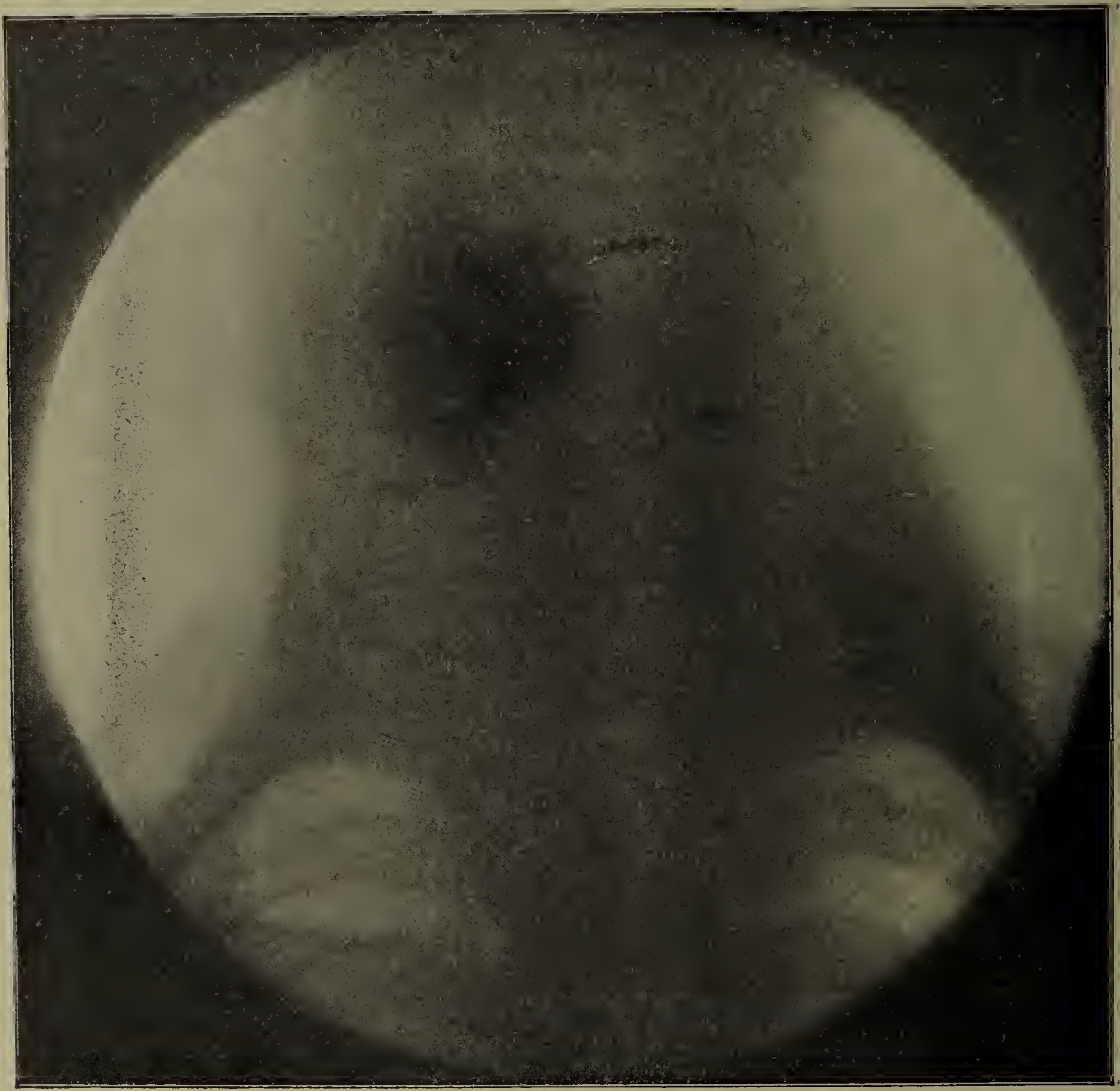


Fig. 181
Sarcoma of the Bodies of the Third and Fourth Cervical Vertebræ.

In intravertebral tumors the bodies of the vertebræ may also be sympathetically affected in a certain measure. While in the rarest forms of soft sarcoma (angiosarcoma) the bodies of the vertebræ may become infected (as I have seen it occur in the case of a woman, fifty-six years of age), in equally rare instances the vertebræ show a picture of atrophy familiar to the surgeon in operations upon the bones of the extremities. In the resection of joints we may occasionally be able to cut the femur or the end of the tibia in adults, with a strong knife. The medullary spaces are widened as a result of disuse, the trabeculæ of the spongiosa are gone or rarified, and the cortical portion is also atrophic. I have seen a similar picture in the otherwise firm arches of the lumbar vertebræ in the case of a woman in her 50's, in whom the 1st to the 3d lumbar vertebræ had to be removed for angiosarcoma of the dura mater. The bone showed a typical picture of atrophy, but was otherwise sound and not affected by the neoplasm.

Spinal Paralyses in Tuberculosis of the Bodies of the Vertebrae

Tuberculous spondylitis may require operation for the kyphosis, intravertebral granulations or, perhaps, accumulations of pus that compress the spinal cord. Compression of the cord is also occasioned when a sequestrum of bone becomes loosened from the body of a vertebra and is displaced into the vertebral canal. Secondary stagnation of liquor to a limited extent may also give rise to paralyses of the cord or contribute to their completion.

Pareses of the extremities of long standing, as well as disturbances of the bladder, anomalies of sensibility and of the reflexes, may improve under treatment by extension. These improvements are brought about by relieving the spinal cord from the kyphotic curvature of the vertebral column, resorption of the vertebral abscesses and by shrinking of the granulations there present. All of these factors may, of course, be operative in one case. This fact indicates that in cases of spondylitic paralyses we may wait a long time. Not only in children but also in adults of forty years or over, in whom I have accomplished the desired results by orthopedic measures, an operation should only be decided upon when the usual methods fail. Of course, we must not wait too long and thereby permit the injured conduction of the spinal cord to become very bad or permanent.

The manifestations produced by compression of the nerve roots and of the spinal cord, are not infrequently developed before positive symptoms of disease of the vertebral column make their appearance. The symptomatology of cases in which caries of the vertebral column has caused only granulation or exudation into the vertebral canal, cannot be clinically distinguished from intravertebral neoplasmata. The course of spondylitis, when symptoms referrible to the roots or involvement of the spinal cord appear, is generally rapid, for we are dealing with inflammatory processes, the œdema of which exercises its morbid influences upon the cord more quickly than the slow-growing tumors. This symptom, however, is not of great value in the differential diagnosis, because transverse lesions may quickly develop in instances of tumor.

It is generally possible, however, to recognize the etiologic factor in paralysis of the spinal cord in caries of the vertebræ. The characteristic changes in the vertebral column are rigidity and pain on movements and sensitiveness to pressure. The sensation of pain is best tested, as recommended by *Friedrich Schultze,* by guiding the finger along the spinous processes of the vertebræ from above downward, or vice versa, asking the patient at what point the sensation changes. So sharp an outline, as found in intra-vertebral tumors, is only exceptionally found in caries. Still, all these symptoms are occasionally observed in cases of tumor, and may therefore be very misleading. Gibbus-formation, and especially the characteristic form of *Pott's* kyphosis, are observed only in tuberculous spondylitis. Only metastatic and primary tumors of the vertebral bodies may give rise to mistakes in this respect. In doubtful cases X-ray examinations should never be omitted.

If **operation** is decided upon, laminectomy is performed, as described above. With reference to the point of surgical attack, this does not always correspond to the point where the gibbus is most prominent, because compression of the cord may be occasioned, as stated above, by granulations, abscesses, or exudation and stagnation of liquor, and also by pathologic processes which are occasionally higher or lower than the seat of the disease in the vertebra. In such cases exact segment diagnosis is of inestimable value for the surgical intervention.

In extensive gibbus-formation special precautions must be taken. Since the individual bodies of the vertebræ are destroyed and the arches have to be taken away, the strength of the vertebral column depends upon the articulations of the transverse processes. It is, therefore, necessary to have the patient in a certain steady position during the operation in order not to injure the cord by careless movements. While the patient is being operated upon, it is best to have some assistants exercise moderate traction upon the lower extremities and shoulders. An especially difficult case follows as an illustration.

OBSERVATION XVIII, 2

Spondylitis of the Thoracic Portion of the Vertebral Column which Became Aggravated After an Acute Attack of Varicella and Culminated in Transverse Paralysis. Abscess of the Mediastinum Posticum. Very Gradual Improvement, but Lasting Cure for Ten Years After Laminectomy and Corresponding Treatment of the Tuberculous Foci.

A boy, six years of age, was brought to the Augusta Hospital in October, 1900, suffering from tuberculous spondylitis at the level of the 8th thoracic vertebra. The kyphosis was rectangular. There was no paralysis of the extremities, the bladder and rectum were not involved and the patellar reflexes were retained. The boy could walk without difficulty. When attempting to pick up an object from the floor, he supported himself with the hand on the anterior side of the thigh. He was discharged from the hospital in November with a plaster-of-Paris corset, and at the end of January, 1901, he returned to have it removed.

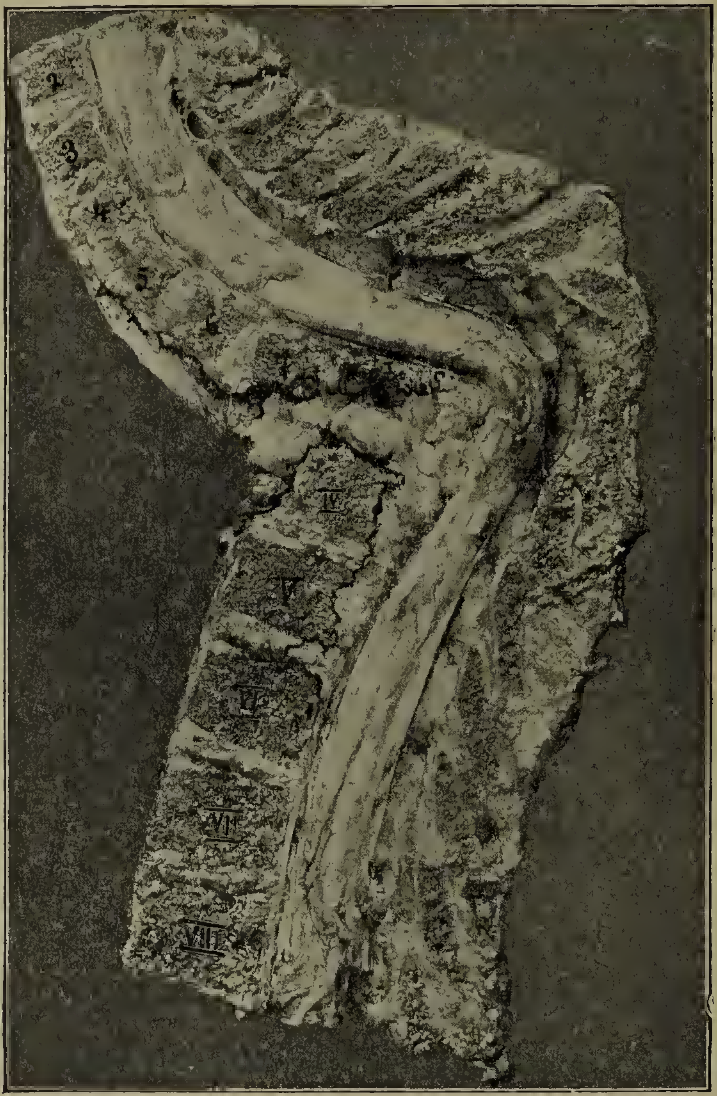
On the 12th of February, 1901, he developed varicella with very extensive eruption, and his trouble became very much aggravated in the following fourteen days, so that he could not stand up without support. The faradic test of all muscles gave good reaction. The cremaster reflexes and the abdominal-wall response were absent below the navel, and above it they were exaggerated. The tests of sensibility showed nothing abnormal. The boy evacuated his bladder and rectum involuntarily, and he was barely able to keep back his urine for ten minutes. He had imperative incontinence (*L. Bruns*).

The progress of the disease was so rapid that in the beginning of May, 1901, both lower extremities showed a spastic paralysis, and the urine and fæces could not be retained at all. His general condition became so much aggravated that the prognosis was very gloomy. The boy later collapsed in his bed with irregular temperature. He was markedly dyspnœic and entirely without appetite, in a condition of extreme dejection. All methods of treatment (*Rauchfuss's* sling, extension and internal therapy) were all useless, and operation was suggested, with very little hope of benefiting, but with thoughts of, perhaps, bringing the evidently hopeless condition to a standstill.

The boy was operated on June 21, 1901. He was so placed that one assistant supported the trunk above the gibbus and another held the pelvis in order to avoid any pulling upon the cord. The removal of the spinous processes and arches of the 5th to 8th thoracic vertebræ with the rongeur forceps showed the vertebral bodies destroyed by tuberculous caries, viz., the two surfaces opposing each other and the third next above on its lower surface. The tuberculous granulations were also found on the anterior wall of the arches to the extent of about 3 cm., elevating themselves about the middle in humplike fashion, so that compression of the cord resulted. The bending corresponded principally to the level of the 7th arch. The conditions were approximately as in the specimen depicted in Fig. 182. The cord was liberated from the pressure exerted by the carious bones and the dura not opened. During the operation a large quantity of pus, intermingled with friable fragments, was evacuated from the right side of the vertebral column. Following up with my index finger the tract from which the pus drained, I came through the softened bones into a large abscess cavity of the vertebral column into the posterior mediastinum. After the abscess cavity was evacuated with small sponges held in forceps and the abscess membrane, bone-sand and cheesy, ragged portions of tissue were removed, a drain was introduced between the two destroyed bodies of the vertebræ and placed into the posterior mediastinum between the bones and the cord protected by the dura, and after the introduction of a number of strips of iodoform gauze the wound was sutured. The dressing surrounded the entire trunk.

It was no small task to manipulate the boy during the operation and thereafter, without causing compression of the already injured cord. Three vertebral bodies were destroyed by the caries, their arches had to be taken away and the firmness of this section of the vertebral column depended upon the joint-connections of the transverse processes. The boy was at first placed flat on his back, and later on for a short time into the abdominal position, and after a few weeks he was permitted to assume any position he desired. He had to be regularly catheterized in the first days following the operation, and he had constant erections.

Fig. 182



Tuberculous Spondylitis in a Boy Eight Years of Age.
The bodies of the second and third thoracic vertebræ completely gone. Only traces of the first body left. Abscess in front of dural sac.

The healing of the wound was satisfactory throughout; the secretion was uncommonly profuse and the dressings were frequently saturated with urine. Despite all this, the wound healed in the course of four weeks, so that the patient could take a bath. Two fistulæ still persisted on the gibbus, which closed gradually and, later on, broke open again for a short time. Now and then irregular elevation of temperature was observed, which could only be attributed to the morbid process within the vertebral canal.

The spastic contractures of the hips and knees which developed in the boy, while in the lateral position (which he preferred), gave us much trouble. All efforts to correct them by the use of extension dressings, splints, sand-bags, and the like, were successful only for a short time, but as soon as the extremities were released they assumed their contracted position again.

The whole summer of 1901 passed without the slightest changes in the paralyses for better or worse. The only consolation we had was that the boy was playful throughout the entire time and that he recuperated wonderfully. He took interest in a great many things and developed an enormous appetite. It is a well-known fact that paralyses in these cases disappear only after a very long time. Finally, about the middle of October, 1901 (almost five months after the operation, after the wound had long been cicatrized firmly), the first signs of regression of the paralyses were noted. The patient was then able to move his left foot voluntarily, to flex it dorsally and plantarward and to rotate it. In the right foot voluntary movements were observed, but to a smaller extent. The spastic contractures unfortunately interfered a great deal with the after-treatment, although they were not as intense as before. Changes in the joints had at that time already developed.

The after-treatment consisted in the use of electricity, massage, warm baths and regular active and passive movements. Efforts were constantly directed to overcome the contractures by padded splints, sand-bags and the like, in which we were finally successful. The boy gradually began to crawl around in bed, at first very awkwardly, and to actively move his lower extremities in the hip and knee joints. From this time on, improvement of the paralyses steadily progressed and, despite the numerous tuberculous abscesses and the left-sided pneumonia (in the fall of 1902), he progressively improved. In August, 1902, the patient made such progress that he was able to use *Volkmann's* walking-stool. In November, 1902, he was able to walk tolerably well when supported with one hand, and when guided by both hands his walk was satisfactory. When he placed his hands into the trapeze rings, he remained in this position for a long time and exercised his lower extremities at will. He was not able to do this before, on account of his weakness. Later on he learned to stand alone and wander around the room along the wall. In June, 1903, he had perfect control over the left lower extremity, but the right was somewhat weaker, and it was in a position of inward rotation, flexion-contracture and pes equinus. Slight spasms were still present in both lower extremities and the reflexes were somewhat exaggerated. The functions of the bladder and rectum were good. The patient was discharged from the hospital and he left for his home.

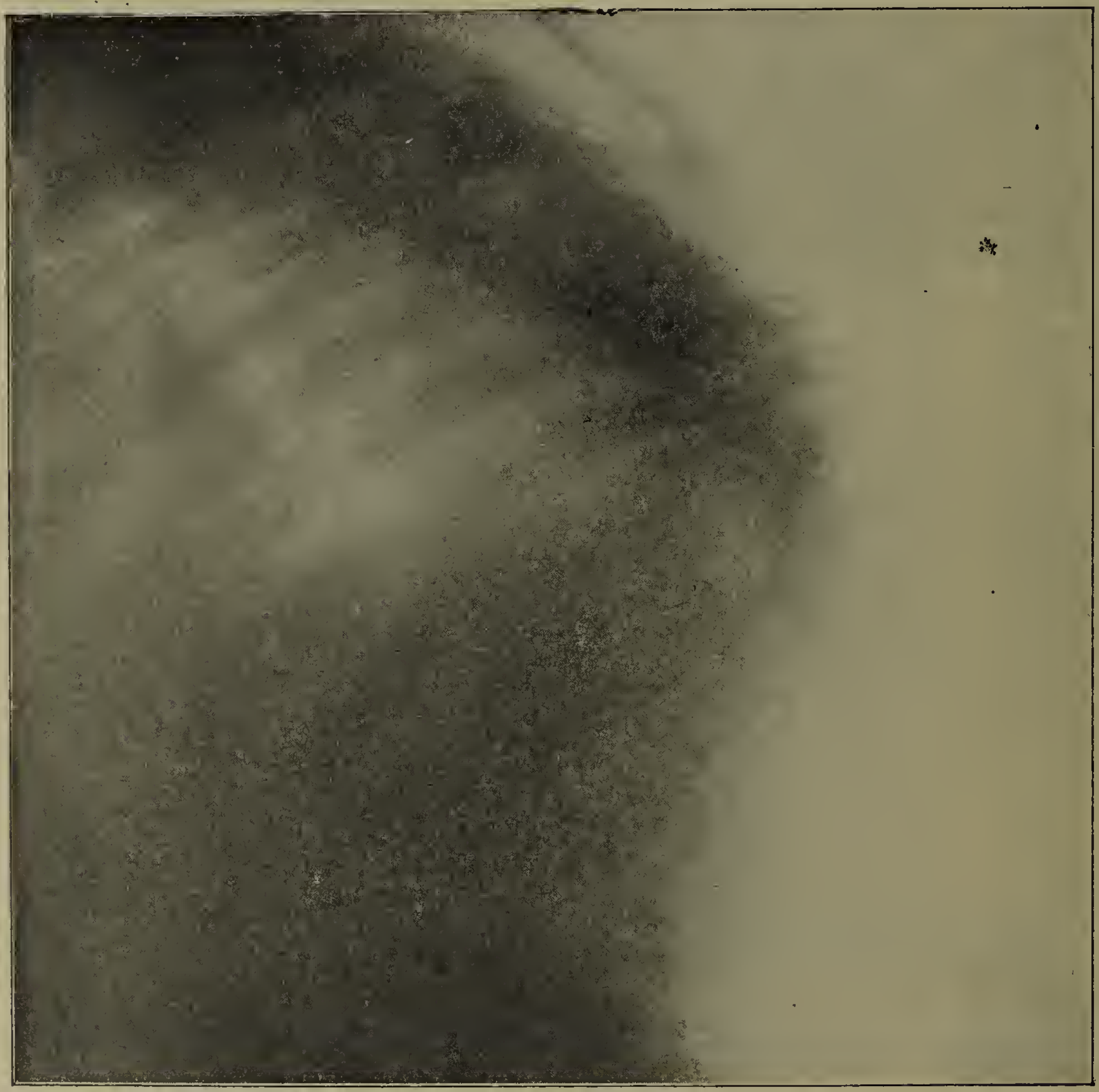


Fig. 183

The twelve-year-old patient, who had meanwhile powerfully developed, came back to us in the middle of October, 1906, to seek relief of the remaining paralyses of the right quadriceps femoris. As a result of these paralyses and the contractures of the flexors, he was able to walk only when he grasped his right thigh with his hand below the middle and strongly pressed it backward. I substituted the paralyzed quadriceps with the flexors of the leg, and since that time the patient has been able to walk about with a splint-apparatus, even without the support of a cane. The gibbus was of the same form as before and is depicted in Figs. 183 and 184.

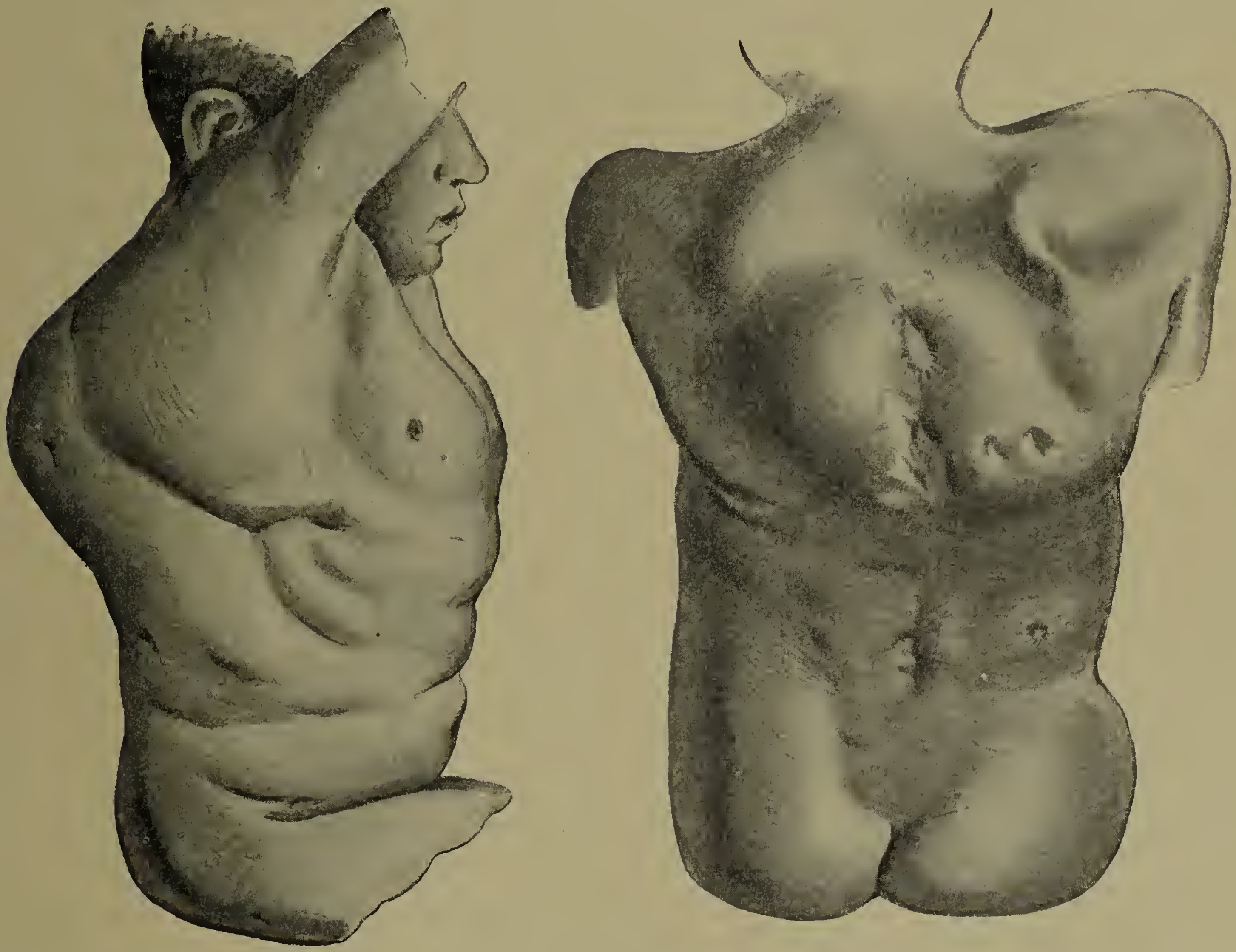


Fig. 184

A report, dated August 22, 1911, informs us that the condition of the patient, who is at present seventeen years of age, is very good. Slight pareses and contractures were present only in the right lower extremity. The extraordinarily severe and extensive tuberculous processes were also completely cured.

In most instances, but not always, the removal of the vertebral arches is sufficient to accomplish decompression of the spinal cord. Yet the cord surrounded by the dura mater may be stretched across an osseous projection in the vertebral canal like a violin-string over the bridge. If the dura is bound down to the surrounding tissues by adhesions, which prevent its getting out of the way, laminectomy alone will not suffice. The dura must then be detached from the posterior surface of the vertebral bodies with an elevator, the cord displaced to the side with great care, and the projecting portions of bone or perhaps a sequestrum removed. If this be successful without traction on the cord, the tuberculous foci may then be thoroughly scraped out with the sharp spoon or with a small, hollow sculptor's chisel. Extreme caution is necessary in handling the nerve roots; for, as stated above, one or two posterior roots, especially of the dorsal portion of the cord, may, if need be, sacrificed without causing appreciable damage.

If the compression be due to an extradural abscess or granulating masses, laminectomy and removal of the morbid exuberances will suffice. Should a recurrence take place, the cord will have room to get out of the reach of the morbid process through the cleft in the bone posteriorly. The opening must, of course, be sufficiently large and extend laterally to the articular processes of the vertebræ. Since I am not particular in saving the periosteum of the arches, regeneration of bone will not take place.

In rare instances where the tuberculous disease originates in the arches of the vertebræ, the compression may be caused by a sequestrum from their anterior surface, in which case the removal of the affected arch will lead to a cure of the original trouble. However, such favorable conditions in caries of the bodies of the vertebræ are extremely rare. Every experienced surgeon knows that surgical tuberculosis is curable and frequently does heal; and that decompression of the cord after a certain time of orthopedic treatment is entirely justifiable, and that the belief that tuberculous foci cannot be entirely eradicated even by extensive operations, is not justified.

Generally speaking, the dura mater should not be opened in these operations, for the masses are extradural within the vertebral canal. Besides, the exposure of the arachnoid spaces may lead to tuberculous infection. However, if there be marked liquor tension and the extradural changes be slight, splitting of the dura in a longitudinal direction is indicated. In order to avoid any possible chance for infection, such operations should exceptionally be performed in two sittings. The dura is then split from five to eight days after the laminectomy, care being taken during the first operation to remove as much as possible of the tuberculous tissue from all recesses and cavities and all exposed surfaces, including the wound in the bone, and the soft tissues being then plugged with iodoform gauze. This drug is still the best in surgical tuberculosis. The muscles and skin may be sutured over the iodoform tampon which projects from the wound. My numerous experiences with bone and joint tuberculosis have taught me that the action of iodoform on tuberculous tissues is greater in wounds from which the air is excluded than in open surfaces. I have reported this in 1890 ("Deutsche medizinische Wochenschrift").

Acute Osteomyelitis of the Vertebral Column

Acute infectious osteomyelitis of the vertebral column occurs, though rarely. As in any other part of the skeleton, the disease attacks young persons by preference and affects most frequently the lumbar portion of the spinal column. The suppurative (frequently multiple) foci may develop in the bodies of the vertebræ, in the arches and their processes. The extension of the suppuration is similar to the propagation of the tuberculous foci—in the intervertebral discs and on the anterior surface of the bodies, where large abscesses may form. It may also break through the lateral articulations on the cervical portion or through the articulation of the atlas. It only rarely happens that the destruction of the vertebral bodies is so great that a gibbus results, as seen in cases of tuberculous spondylitis.

The observation of importance in this respect is the fact that the spinal cord may in these cases be sympathetically affected either by an accumulation of pus within the vertebral canal alone, or the inflammatory œdema consequent to the focus of infection may easily lead to severe manifestations of compression. Besides this, the soft membranes and the cord may, of course, occasionally be involved by direct infection.

The disease usually runs its course under the manifestations of an acute infectious osteomyelitis with the familiar clinical picture of typhoid ("typhus des membres"); but there are also subacute and chronic forms which are not always to be distinguished from tuberculous spondylitis.

Abscess-formation in the posterior and lateral portions of the entire vertebral column and also those affecting the anterior portions of the cervical and lumbar sections are readily diagnosed. Their recognition, however, is more difficult when the thoracic portion is affected, in which case the pleura may become infected. Early wide-opening of the foci of infection alone prevents dangerous extension of the disease and often pyæmia.

The foci in the bone should be exposed and drained—a condition which is not always possible when the bodies of the vertebræ are diseased. If there be manifestations of compression of the spinal cord, laminectomy must be performed, and the careful displacement of the sac of dura to the side may enable us to reach the posterior surface of the bodies of the vertebræ, as previously described. The results in advanced meningitis by opening and drainage of the dura are not promising, yet in view of the entire hopelessness of the condition, it may be tried. For the sake of completeness it may be mentioned that we have also to contend with **Typhoid Spondylitis** which affects principally the lumbar vertebræ. The disease is the result of typhoid fever, and appears during its course, or two or three months after its cure. Cases of spondylitis, the result of influenza, pneumonia, and empyema, have also been reported.

Syphilis and Actinomycosis of the Vertebral Column

Osteochondritis and Syphilitic Periostitis of the vertebral column usually appear as tertiary manifestations of the disease and affect mainly the upper cervical vertebræ. It is a real gummous caries, and the clinical manifestations of the disease are almost inseparable from those of tuberculous caries, for the picture presented by both is about the same, and in this instance it also leads to gibbus formation and sequestra. As in tuberculosis, the dura mater and spinal cord may be similarly affected. Cases are reported in which periosteal intravertebral gummata have given rise to severe manifestations of compression.

Actinomycosis of the vertebral column is always a secondary disease if the affection extends from the neighboring viscera and involves sympathetically the ligamentum longitudinale anterius as well as the bodies of the vertebræ. The symptoms of the organs first affected dominate the clinical picture, and manifestations referrible to the vertebral column occur in the later stages of the disease, when a cure by the use of potassium iodide or surgical measures can no longer be expected.

Injuries of the Spinal Cord

Any violence to the vertebral column may give rise to injury of the spinal cord. The range of injury is great and it may be a simple concussion or a complete traumatic destruction; the symptoms alone will, only in a few instances, enable us to make a positive diagnosis as to the severity of the injury to the cord. *Concussion of the cord* (commotio), and, to a greater degree, *contusion,* may give rise to more or less complete interruption of conduction. However, these disturbances usually regress, at least in part.

If the paralysis of the cord continues, its perpetuation may be caused by the following morbid influences: extra- or intradural extravasations of blood, splinters of bone and divers foreign bodies (bullets, point of a knife, etc.), which gain entrance into the vertebral canal. The displacement of fragments of bone or dislocated parts of the vertebral column may finally be the etiologic factor.

Stab-Wounds

may injure the spinal cord and its membranes, without touching the bones of the vertebral column. This happens when the blade inflicting the stab finds sufficient room to enter between the vertebral arches. Even, when a spinous process or a vertebral arch is perforated, the severity of the injury depends exclusively upon the degree of trauma inflicted upon the central organ, i.e., it depends upon whether the cut is produced by a sharp knife or whether it remains aseptic or becomes infected. A blunt-pointed blade may reach the dura and without cutting through it, contuse the cord. More frequently, however, the damaging instrument cuts through the dura and enters the central organ.

Of all other forms of injury, stab-wounds are by far the most frequent cause of *Brown-Séquard's* lateral lesion, even when the division does not affect exactly half of the transverse section of the cord. The secondary manifestations, developing in connection with trauma (hemorrhages, œdema, inflammatory breaking down), complete the symptom-complexus. If the stab be oblique, the opposite half of the cord alone may be involved. *Brown-Séquard's* paralysis does not naturally correspond to the entrance of the instrument.

Leakage of liquor cerebro-spinalis is not invariably the result. The thickness of the divided soft tissues are sufficient to prevent it.

A recent stab-wound is hardly an indication for operative intervention, if there be no severe hemorrhage. The usual disinfection and aseptic bandage are sufficient. Probing is absolutely contraindicated. Contused, ragged, and dirty wounds should be treated according to general principles. Foreign bodies of metallic nature are discovered by the X-ray and, if causing manifestations, should be removed. Otherwise, they are best left alone, for they may heal without reaction.

Bullet-Wounds

are frequently associated with complete transverse division of the spinal cord. In other cases, again, splinters of bone may be dislocated into the sac of dura, and the cord may be contused or torn to a considerable extent. According to my experience, a severe contusion of the cord, without injury to the dura mater, may lead to incurable interruption of conduction. I observed this sad occurrence in a man, thirty years of age, in whom a bullet, fired from a *Browning* pistol, tore off the spinous process and arch of the 1st lumbar vertebra from right to left, and superficially injured the dura mater. A few months after the injury the patient was brought to me with progressive paralysis. Laminectomy showed the dura unchanged outside of blood pigmentation, and when split longitudinally it showed the cord apparently normal to inspection and palpation—maybe a little swollen. In order to gain a certain degree of decompression, the arch of the 2d lumbar vertebra was also taken away, the dura split to the entire extent of the cleft in the bone and not sutured, and the muscles and skin united in the usual manner. The paralysis persisted as before.

Bullet-wounds of the spinal cord are, as a rule, more severe than stab-wounds. At any rate, they require more frequent surgical intervention on account of the larger size of the wound, hemorrhage or foreign bodies which exercise pressure (projectile or torn-off portions of bone). It is best to operate after overcoming the collapse (about one or two days after the infliction of the injury), if severe hemorrhage does not indicate immediate interference.

The technic of operation is that of an atypical laminectomy with the removal of one or more arches, in order to completely inspect the injured parts. Coagula of blood, splinters of bone as well as the bullet, which frequently cause severe deformity and division of various structures, should be carefully removed in order to avoid further injury of the spinal cord. Ragged soft tissues, torn dura and soft membranes of the spinal cord are taken away. Even though the dura mater be uninjured, it will have to be opened in most instances, because an intradural extravasation of blood or an abnormal accumulation of liquor may perpetuate the compression of the cord.

Injuries to the Spinal Cord from Dislocation and Fractures of the Vertebral Column

Both of these injuries are frequently combined. Isolated dislocations of the lateral articulations, as seen especially in the cervical portion of the vertebral column as well as isolated fractures of the bodies of the vertebræ which mainly affect the thoracic and lumbar portions, will frequently give rise to symptoms of irritation from the roots, and sometimes of the spinal cord. Manifestations of compression of the cord of greater or less degree are added when this organ suffers from concussion, contusion, or hemorrhage.

Even in these cases a careful attempt at reduction of the dislocation should be made. Extension alone is insufficient, if the thoracic and lumbar portions of the cord be affected. These cases should be treated by *Rauchfuss'* sling or a properly padded firm roll. If this procedure does not improve the paralyses, or if the condition be aggravated, opening of the vertebral canal should not be delayed. Insufficient fixation of the fragments, serous extravasations and secondary hemorrhages, are then the cause of the new manifestations and increase the dangers of compression of the spinal cord by delaying the operation.

Generally speaking, the lesions of the cord, following the thus far mentioned injuries of the vertebral column, are not marked, if greater displacement of the fragments does not occur. On the other hand, they will be severe in instances of *bilateral luxation of the lateral articulations with tearing of the inter-vertebral discs.*

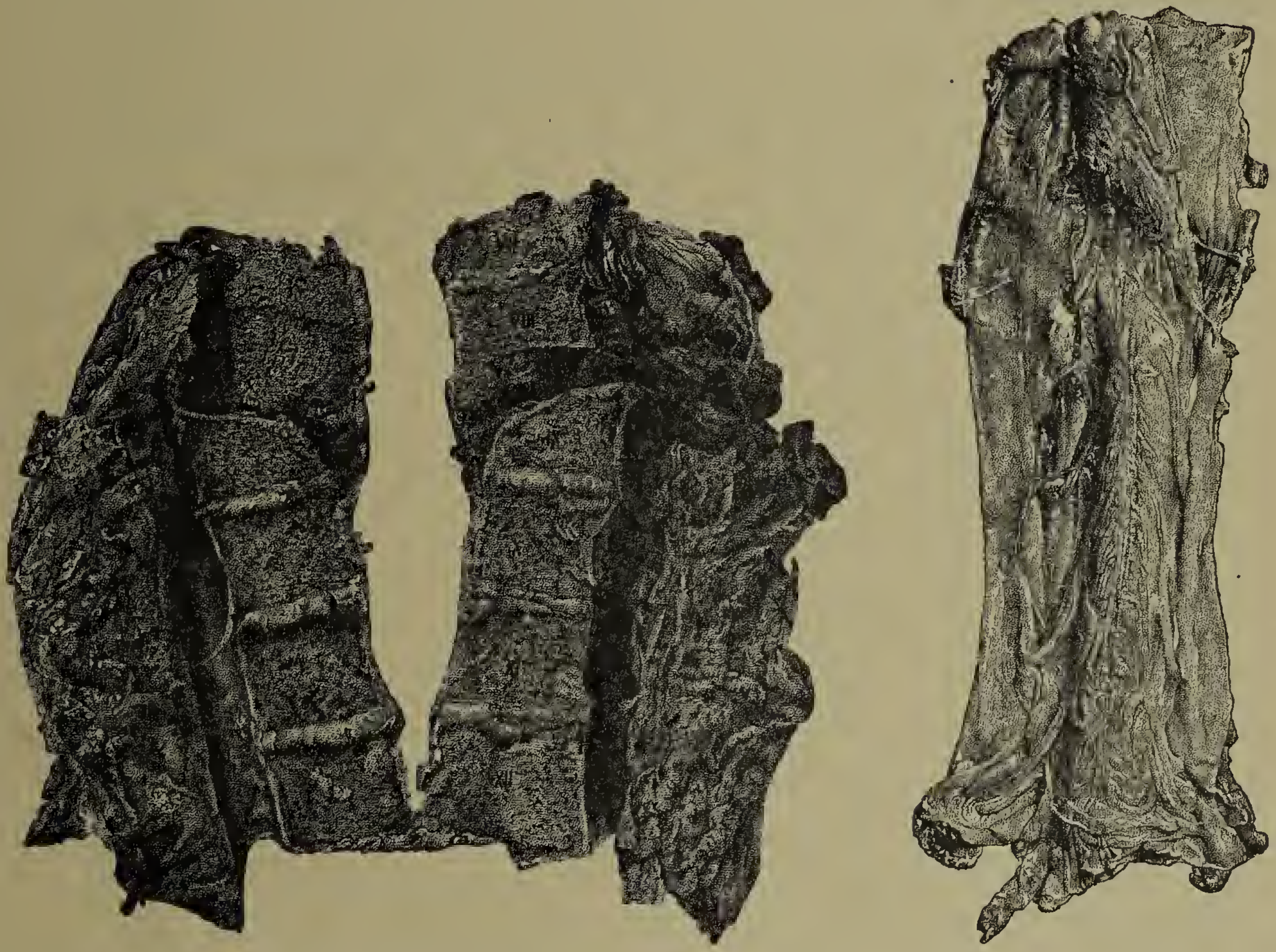


Fig. 185

Fracture-Dislocation of the Eighth Inter-Vertebral Disc, with Complete Division of the Spinal Cord.

Transverse or oblique fractures of the bodies of the vertebræ may also occur, and this will be the case if the inter-vertebral cartilage be more resistant or elastic than the body of the vertebra. Instead of a dislocation of the lateral articulation, the articulations may be broken off for the same reason. These injuries are caused by violent compression of the trunk, especially when the pelvis is fixed, i.e., when the patient is found in a standing position in a narrow space.

The injury of the spinal cord will depend upon the line of fracture and the nature of the luxation. The application of force, sufficient to cause a solution of continuity in the very flexible vertebral column, will injure the soft cord to the extreme. Therefore, the more rigid the spinal column and the thorax as age advances, the greater the liability to injuries of this nature. Frequently a transverse fracture of the sternum results. I recall the case of a man, fifty years of age, in whom there was a lateral dislocation of the 8th thoracic vertebra in which the X-ray showed the body of the vertebra dislocated to such an extreme point that it barely touched its neighbor. The result, of course, was complete transverse division of the cord (see Fig. 185).

In bilateral luxation of the cervical portion of the cord, abduction and rotation are absent and flexion is, therefore, greater. A distinct diastasis is demonstrable on the spinous processes, and also a displacement of the upper portion of the vertebra to the front. This, of course, at once shows that double dislocation jeopardizes the spinal cord to a greater extent than unilateral accidents. We, therefore, try extension, which is gradually increased in force, to loosen the dislocated articular processes from one another, and by careful deflexion and backward motion to reposit the dislocated portion of the vertebral column. During these manœuvres the patient is placed on his back (as taught by *Wagner-Stolper*) in such a manner, that his head and neck and, if necessary, the thorax reach beyond the table. The shoulders are retained in position by an assistant. Since flexion of the neck increases the degree of dislocation and thereby places the cord in greater danger, its practice is to be condemned.

Fractures of the Arches of the Vertebrae

are finally produced by direct and indirect violence. They are frequently observed in combination with other injuries of the vertebræ. While less frequently, they may, nevertheless, give rise to severe contusions of the cord, they principally cause compression of the spinal cord by a displacement of the broken fragment projecting into the vertebral canal. In these cases operation should be undertaken at once.

In all fractures and dislocations of the vertebral column, X-ray examination is indispensable. Without adding danger to the spinal cord, it clears up the diagnosis and suggests methods of reposition.

Regeneration of Contused and Divided Fibres of the Spinal Cord

in men seems impossible, although *von Ströbe,* and after him, *Bär, Dawson,* and *Marshall* showed a regeneration of the fibres of the posterior roots which were severed between the spinal ganglia and the cord. A few favorable reports come from America. *Briggs,* for instance, found in 1898 a complete division of the spinal cord at the level of the 10th dorsal vertebra, following a fracture of the vertebral column in a youth of seventeen, three weeks after the accident. He freshened both ends and united them with catgut sutures. The functions of the bladder and the muscles of the extremities returned very gradually. *Esté* has sutured the posterior and lateral columns and has observed an almost immediate improvement in sensibility.

The following cases of great importance to the question at issue are more important and are carefully observed. *Stewart* and *Harte*[1] united the spinal cord which was severed by a bullet, at the level of the 7th thoracic vertebra in a woman, twenty-six years of age. In this case the ends of the cord were separated from one another for a distance of over 2 cm. The operation was performed three hours after the accident and catgut was used for suture material. Fourteen days after the operation the first signs of restoration of conduction were observed. Eight months after the operation the patient was able to walk when supported on both sides. The sense of touch, temperature, and pain as well as the sense of position, together with the skin and periosteal reflexes returned. With the exception of nocturnal enuresis, the functions of the bladder and the rectum obeyed the will. Sixteen months after the operation active movements of the lower extremities and toes could be performed by the patient, and five years thereafter (1906) the patient was able to walk a few steps with the aid of crutches.

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[1] *Stewart* and *Harte,* A Case of Severed Spinal Cord in which Myelorrhaphy was followed by Partial Return of Function. "Philadelphia Med. Journ.," 1902, Vol. IX, p. 23.

Fowler,[1] in 1903, united the cord with three catgut sutures at the level of the 11th dorsal vertebra, but with very slight success. He casually remarks that the slight improvement noted in his case may have been due to the fact, that a portion of the cord was not divided or that some anastomoses had formed at the point where the dura mater was not severed. He suspects the same to have happened in the observation of *S. Harte.*

At present the statement that the function of the divided fibres of the spinal cord may be restored by direct union or regeneration, must be accepted with great scepticism. Even in those favorable cases in which only a portion of the cord has been previously divided by a stab-wound, shot or other form of violence and the neighboring fibre tracts remain in their normal relations, no regeneration is seen to take place. Of course, the sympathetically affected and paralyzed tracts immediately following the accident may recuperate and have their functions more or less completely restored, without an actual regeneration of the fibres having taken place.

For the sake of completeness, it should be mentioned that *Shirres*[2] has implanted a portion of the spinal cord of a large dog, in a case of complete division of the cord with loss of about three inches. At the autopsy, made three months later, besides the usual degenerations of *Goll's* and *Burdach's* columns and the pyramidal tracts, a very limited newformation of nerve fibres was found on both ends of the cord and in the neighborhood of the dura mater.

Hemorrhages Into the Vertebral Canal

may be found in all injuries and they may be intra- or extradural. In the latter case they will exert no pressure upon the spinal cord except when of extraordinary dimensions. In cases of intradural hemorrhages the sections will show them to consist of layers of greater or less thickness surrounding the cord, occasionally in its entire circumference. If these be limited, even to a smaller area, they will necessarily result in corresponding manifestations of compression.

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[1] *G. R. Fowler,* A Case of Suture of the Spinal Cord following a Gunshot Injury Involving Complete Severance of the Structure. "Ann. of Surg.," 1905, Vol XLII, No. 4.

[2] *D. A. Shirres,* Regeneration of Axones of Spinal Neurones in Man. "Montreal Med. Journ.," 1905, Vol. XXXIV, No. 4, April.

In view of this fact, it will only be necessary, in a few instances, to operate for extra- or intra-dural extravasations of blood alone. Lumbar puncture, in cases of intradural hemorrhages, will not only clear up the diagnosis, but is an excellent therapeutic measure, since experience teaches that the evacuation of even a part of the extravasated blood will initiate the resorption of the rest of the exudation. In most cases, however, the extravasation of blood is only a secondary symptom to severe injuries of the vertebral column or the cord, and then, of course, it fades into insignificance, compared with the main lesion.

Haematomyelia

Conditions are different in cases of intramedullary extravasations of blood which affect the gray substance by preference and lead to the severest symptoms.

Such hemorrhages may result in comparatively slight injuries by violence, where excessive movements of the vertebral column pull upon the cord or cause it to be contused. The mobile portions of the spinal column, such as the cervical and the lumbar portion, are most frequently affected. The symptoms are produced either by an immediate destruction of the fibre tracts or by the pressure exercised by the extravasated blood. There may be an interruption of conduction of individual columns or of the entire transverse section of the cord; to these, symptoms of irritation of the posterior nerve roots are added. In small hemorrhages the prognosis is not unfavorable. However, many weeks, nay months, will pass before the restoration of the disturbed functions will take place. Frequently, only very limited restoration will be observed, especially in those cases where many fibres were affected as a result of the extravasation of blood.

Generally speaking, laminectomy will be performed in these cases only when other indications are present—a splinter of bone, for instance, compressing the cord. In hemorrhage, pure and simple, the operation accomplishes nothing, and is justified only when injury of the cord complicates the condition. We generally will be able to ascertain the seat of the trouble by the aid of segmental diagnosis; but we remain entirely in the dark as to whether the extravasated blood in the cord forms a real cavity and is in a fluid state, so that it may be evacuated, or whether it has already coagulated. For these reasons operative intervention in cases of hæmatomyelia is hardly indicated.

Indications for Laminectomy

In instances of complicated fractures and dislocations, in bullet and stab wounds, and in any injury in which the traumatization indicates surgical intervention, the question of immediate exposure of the spinal cord must be considered. In other cases, with the exception of a few instances of which I shall speak directly, the patient should be placed in a proper position horizontally on a water cushion, and then we wait to see how far the existing paralyses of the spinal cord will regress, while we are using extension. The functions of the rectum and bladder in cases of injury of the spinal cord, should receive the greatest possible attention. A note of warning should be sounded here with reference to the irregular use of the catheter in disturbed bladder function, which may invite serious complications. The skin should finally receive proper attention, especially those portions of the body mainly exposed to pressure, and decubitus should be avoided as much as possible.

Even in partial division of the spinal cord, symptoms of a complete transverse lesion are frequently present. Gradually, however, the morbid manifestations will disappear, and the recurrence of some functions and the absence of others will enable us to make a correct diagnosis. For this reason it is best to abstain from immediate operation, and treat surgically only external wounds. An indication for operation is found when a splinter of bone, as for instance, in cases of isolated fractures of the arch of a vertebra, or a bullet, is the cause of compression. In both of these cases the X-ray picture is of inestimable value. Operation is also justified where other complications jeopardize the patient suffering from dislocation or fracture of the vertebral column, or where a reduced dislocation resumes its abnormal position and perpetuates serious symptoms.

If the nervous disturbances continue, and if the patient who improved in the beginning becomes worse, an operation is indicated. In cases of fracture the etiologic factor may be callus-formation, and in other instances a constricting scar, and, again in others, a circumscribed accumulation of liquor cerebro-spinalis (meningitis serosa ex arachnitide adhæsiva) may perpetuate the symptoms.

Complete interruption of conduction of the spinal cord is so hopeless a condition that, even though no sharp indication exist, laminectomy with splitting of the dura, especially in young, strong persons, is to be taken into consideration when orthopedic treatment has failed. The operation is performed by opening the vertebral canal in the manner described above. All bodies exercising pressure (blood-clots, splinters and dislocated portions of bone), should be removed or chiselled away. Displacements should be corrected and their recurrence prevented. This, of course, is not always an easy matter to accomplish, and it depends upon circumstances whether we may expect good results by proper position of the patient alone, or by suturing the adjacent spinous processes with silver wire (*Hadra*) or have recourse to similar measures.

Suture of the divided spinal cord, as practised in America, has thus far unfortunately shown no good results.

I shall not enter into a discussion of cerebral hernia and spina bifida. Both (myelocele, myelo-cystocele or meningocele) show so few diagnostic and operative differences, that I did not think it necessary to enter into their discussion in this work.

I have given two instances of *perforating sarcoma of the dura* in Observations VI, 3, Vol. II, p. 658, and VI, 4, p. 661. They had to be dealt with in that chapter for physiologic reasons.

END OF THIRD VOLUME.

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